Brimleyana

The Journal of the North Carolina State Museum of Natural History

number 1 march 1979

Brimleyana, the Journal of the North Carolina State Museum of Natural History, will appear at irregular intervals in consecutively numbered issues. Contents will emphasize zoology and general ecology of the southeastern United States, especially North Carolina and adjacent areas. Geographic coverage will include AL, DE, FL, GA, KY, LA, MD, MS, NC, SC, TN, VA and WV. Suitability of manuscripts will be determined by the Editorial Board, and each paper adjudged suitable will be reviewed by appropriate specialists. Final acceptability will be decided by the Editor.

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In citations please use the full name—Brimleyana.

ISSN: BRIMD7

About the name of this journal . . .

The Brothers Brimley: North Carolina Naturalists

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During the middle years of the nineteenth century two sons were born into a family of long time farmers living near Bedford in the midlands section of England, northwest of London. One made his appearance at the family home in the village of Willington, Bedfordshire, on March 7, 1861; the other, a "seven months" baby, arrived unexpectedly at the home of his maternal grandmother at Great Linford, Buckinghamshire, on December 18, 1863. In their early youth, as the younger of them was to write many years later, they "collected birds' eggs, caught small birds in brick traps in the winter, went fishing, and meddled with living creatures in general after the usual fashion of boys" and "had a reasonably good working knowledge of the wild life around us." No one could then have guessed, however, that these English farm lads would one day be recognized as two of the most remarkable naturalists of their time in the southeastern United States.

Their first step in this direction was initiated by misfortune and guided by chance. Agriculture in England had experienced a series of poor seasons in the 1870s, and by the end of the decade farm prices were at an all time low. The family faced the sad reality that its only hope for new beginnings lay in emigration to a distant land and made tentative plans for a move to Australia or Canada. But before their plans became final, an essentially accidental meeting with an official of the newly-formed North Carolina Department of Agriculture, Immigration and Statistics convinced them that America would be their Land of Opportunity.

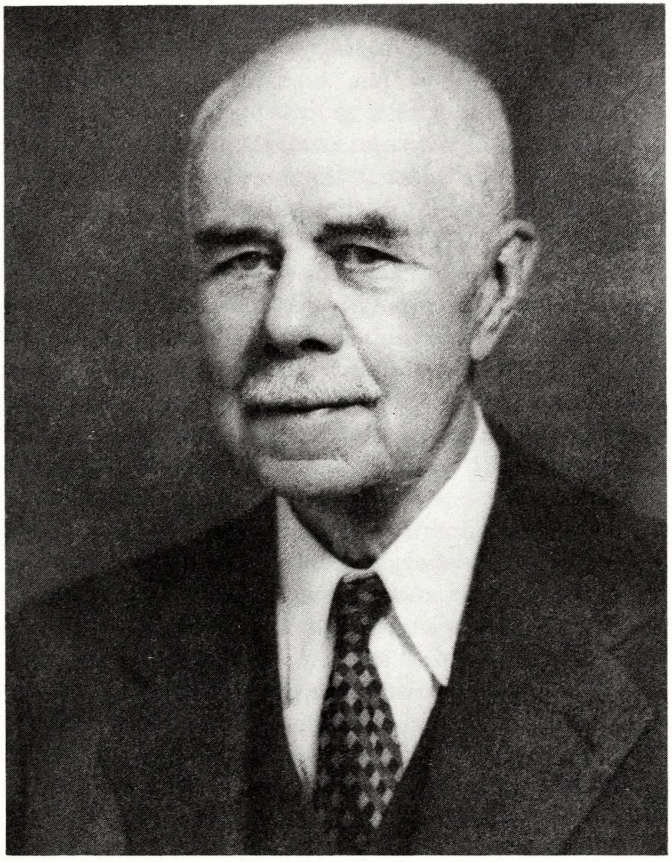
Late on the night of December 31, 1880, Herbert Hutchinson Brimley, nearly 20 years old, and Clement Samuel Brimley, barely 17, having crossed the Atlantic by steamer to New York, arrived in Raleigh on the heels of a blizzard. With them were their parents, Joseph and Harriet, two sisters, and one of two living brothers. Their first stop was at a hotel which, less than a year later, became the Agriculture Building, the very place where they would ultimately labor for much of their lives. H.H. Brimley's remembrance of that time was written almost 50 years later:

> "My first impression of Raleigh was that it was without question the damndest place I had ever seen. Expecting to jump directly into

Clement Samuel Brimley
December 18, 1863 — July 23, 1946

the justly celebrated Sunny South, irrespective of time of the year (December 31, 1880), I found a town with unpaved streets, ruts hub-deep, frozen solid and covered with snow, and the temperature down mighty close to zero. There were some board sidewalks, but military tanks or caterpillar tractors would have been the only suitable vehicles for negotiating those streets under the prevailing conditions.

"The hotel, later used as the Agriculture Building, was not equipped with running water, and that in the pitcher in the bedroom I occupied was frozen solid. We had to pull up the carpets and use them for blankets to keep from freezing to death the first night, no artificial heat being provided in the rooms. Bedford, even at the



Herbert Hutchinson Brimley
March 7, 1861 — April 4, 1946

time known as an educational center, had paved streets and running water in the houses. Raleigh depended on wells under the sidewalks equipped with wooden pumps for its public water supply. Backyard and frontyard wells and pumps supplied some of the more pretentious residences. In short, Bedford was a more or less finished town, for its time. Raleigh conveyed the impression of being comparatively raw—the cows and hogs roamed the streets, giving it something of a rural atmosphere. However, there was a restless, pulsing air about the place and its people that impressed me."

The Brimleys soon found that their new land was not exactly an agrarian paradise, and their attempts at farming the rocky Piedmont soil

near Method, between what is now west-central Raleigh and Cary, were of limited success. H.H. turned to teaching in a one-room log schoolhouse in House Creek Township near the site of present Meredith College, but this venture also ended in failure, at least partly because his English accent and the southern drawl of his students proved incompatible. In his words, "I will never know which of the three bodies were happier when I resigned—the school committee, the students or myself. We just could not understand each other."

Fortunately, although not endowed with much in the way of worldly possessions, H.H. and C.S. brought with them two incredibly inquisitive minds and an intense interest in nature developed in the hedgerows and fields of the Ouse River valley. Immediately upon arriving in their adopted land, and as time permitted between various unsuccessful attempts at earning a living, they set about studying its wild creatures, especially the birds. Sometime in 1882 or 1883 they came into possession of a 50-cent book entitled *Taxidermy Without a Teacher*, and began dabbling in the art of mounting and modeling animals. As their skills in this field developed, especially those of H.H., a whole new enterprise enabling them to indulge their love for the outdoors and natural history collecting opened before them, and they drifted into a business under the name of "Brimley Bros., Collectors and Preparers." In 1942 H.H. wrote, "Following our arrival in Raleigh in 1880 the main activity of my brother, C.S., and I in endeavoring to keep the justly celebrated wolf from the not-too-securely fastened door was a crude grade of custom taxidermy together with the collecting of bird skins and eggs for wealthy men in the big cities, who vied with each other over the comparative magnitude of their collections." As we shall see, these unsure commercial beginnings were the foundations of two outstanding careers in natural history.

At about the time the Brimleys were just beginning their "meddling with living creatures," and probably well before either had ever heard of North Carolina, a series of events was unfolding here, which, in retrospect, almost seemed tied to them by some arcane cosmic threads. They culminated in formation on March 12, 1877 of the N.C. Department of Agriculture, Immigration and Statistics, and appointment of the first commissioner of agriculture, Colonel Leonidas Lafayette Polk. Some time before assuming this office Polk had urged the State Grange to establish a central headquarters containing a "Patron's State Musuem" for the display of North Carolina's agricultural products. Shortly after becoming commissioner he began such a museum himself in a room adjoining his office in the Briggs Building on Fayetteville Street in Raleigh, which since 1875 had also housed the Geological Survey. Washington Caruthers Kerr, state geologist, was maintaining a mineral collection

there, and often referred to it as the "geological museum" and even "state museum." There were, in effect, two distinct "state museums" under one roof, neither of them officially so designated. The mineral cabinet, however, was a legal state collection, dating at least to the mid-1850s when the General Assembly required Ebenezer Emmons, Kerr's predecessor, to establish such a display in the State Capitol. At any rate, on February 20, 1879 the legislature placed the survey under the jurisdiction of the Department of Agriculture and required the commissioner, "by and with the consent and advice of the Board of Agriculture" to keep a "museum or collection to illustrate the agricultural and other resources and the natural history of the State." The geological and agriculatural collections were thus combined under this broader mandate, and the State Museum was founded.

In 1881 the Department of Agriculture purchased the old National Hotel (site of the Brimleys' first Raleigh stop) to consolidate its offices. The museum was assigned part of the space for displays and other collections, which included the remnants of exhibits made by the Board of Agriculture at a number of expositions in this country and abroad. North Carolina's participation in such expositions had proved quite advantageous to a variety of economic enterprises, and the state's committment to them continued. As the time for the 1884 State Centennial Exposition at Raleigh approached, H.H. Brimley's growing reputation as a taxidermist and preparator came to the attention of the board, which was planning and assembling exhibits on North Carolina's resources. Consequently he was hired to mount a series of fishes for the display, under the direction of Stephen G. Worth, superintendent of fish and fisheries. Brimley also made a collection of waterfowl from Currituck Sound for this exposition, as recounted in "Old Times on Currituck," published in *North Carolina Wildlife Conservation* for March 1943.

The Brimley brothers' partnership became a going concern and gave them marvelous excuse to collect and study the animals of North Carolina, about which little was known at that time. Although they were in the natural history business to earn a living, their intellectual interests were not subordinated. 1884, in addition to being noteworthy as the year of H.H. Brimley's first employment by the Board of Agriculture, was also the year in which the brothers began publication of a series of notes on a new and exciting fauna. Initially their contributions concerned birds, and most appeared in the pages of *Ornithologist and Oölogist*. These were only the first efforts, however, in a long series of publications covering many topics in a noteworthy array of journals, magazines, and newspapers.

In 1890 planning began for participation in the great World's Columbian Exposition of 1893, and the State World's Fair Commission did not

hesitate to select H.H. Brimley to collect and prepare native animals for the North Carolina exhibits. He assembled and installed the Fish and Fisheries Exhibit, which again included "aquatic birds," and remained with it in Chicago throughout the exposition. The voluminous collections gathered for the state's many displays, too excellent and valuable to discard or relegate to storage, were directed by legislative action to join the State Musuem upon their return to Raleigh. This further strained the holding capacity of its none-too-capacious quarters, although the available space had been nearly doubled by a minor addition in 1893, and the collections remained rather jumbled and unusable. Among the pile of materials were the disassembled bones of a Right whale known as "Mayflower," and in 1894, not long after returning from Chicago, H.H. Brimley was again hired by the board, this time for the singular task of articulating and mounting the 46-foot skeleton for display. Since the budget lacked money for such odd work he was hired under the job title of "fertilizer inspector," as shown in the expenditure ledgers for that year. The task took about three months, and this early piece of Brimley handiwork is still on display at the museum.

On April 15, 1895 the next logical step in the inexorable progression was taken, and a new era signalled for the State Museum, when H.H. Brimley was appointed its first full-time curator. He was also the sole employee and, as he wrote later, "I became expert with a feather duster and pushed a wicked carpet sweeper! I had no funds beyond my princely salary of $75 per month." His title remained curator until 1928, when it was changed to director. H.H. continued to collect, prepare, ship, erect, and occasionally to man the North Carolina exhibits at major fairs and expositions. Each resulted in the addition of more and more collections to the State Museum and the accumulation of a store of information on North Carolina's natural history. An ever-growing fund of this information was put into print in papers by the Brimleys. Not yet employed by the state, C.S. mainly devoted his efforts to "Brimley Bros., Collectors and Preparers." H.H. also continued to work in the business on a part-time basis until 1907 or 1908, when he dropped out to devote his full energies to the growing museum. By this time he had an assistant curator, Tom Adickes, and a janitor, Bob Alston (who presumably relieved the curator of his feather duster and carpet sweeper). The museum now occupied the entire second floor of the Agriculture Building, as well as another annex added in 1897.

In those early days the museum's holdings, as listed in the 1897 *Hand Book of the North Carolina State Museum*, were diverse and even somewhat cosmopolitan. Emphasis, of course, was on the geological and agricultural resources of North Carolina, an immediate legacy of the

blending of survey collections with those assembled by Commissioner Polk. By 1900, according to Curator Brimley's report for that year, the museum had accumulated "more than 100,000 specimens illustrative of North Carolina . . . ." Although many of the materials obviously provided data on the natural history of the state, there were at that time no collections maintained for purely scientific purposes. In this same report, however, H.H. provided a portent of things to come, saying, "The Zoological Department will be extended until the collections embrace specimens of all the animal life native to the State." And, "Attention will also be given to the flora of the State, and collections begun in that line. This feature is at present unrepresented in the Museum." From the time of this committment the museum moved steadily forward in most areas of natural history. The old "National Hotel" was demolished in 1922 to make way for a modern agriculture building, and the enlarged museum reopened there in 1925.

H.H. Brimley continued to publish occasional zoological papers almost until his death and received the singular honor in 1934 of being elected to full membership in the American Ornithologists' Union, joining a select assemblage of 150 of the nation's top students of birds. He was the only North Carolinian to enjoy this privilege for quite a long time. Nevertheless, his major talents were in areas other than technical reporting. His reputation as a preparator of specimens and exhibits climbed rapidly after he became curator of the State Museum. Among his many accomplishments, assisted by various co-workers, were the modeling of a giant Ocean sunfish which weighed 1200 pounds and was seven feet long and eight feet high; articulating and mounting the skeleton of a 54-foot Sperm whale estimated to weigh more than 50-tons in the flesh; modeling a 17-foot Beaked whale and its fetus; modeling parts of a 35-foot Whale shark, and whole modeling a 14-foot Basking shark and a large Nurse shark; mounting and partially restoring the skeletal elements of a mammoth; and mounting hundreds of other animals used in showcase exhibits which he planned and prepared. He published a number of papers on his methods and techniques and presented talks on the same subjects at professional meetings. One such presentation, describing methods of obtaining, preparing, and mounting whale skeletons, was made at the 1929 meetings of the American Association of Museums and published in *The Museum Years* for November 1930. He was a lifelong member of the AAS and seldom missed its annual meetings, often attending at his own expense. He also belonged to the Museums' Association of Great Britain.

Throughout his life, even into old age, H.H. was an obsessive outdoorsman whose favorite activities included hunting and fishing, to which

he brought a scholar's attentions. Because of his deep involvement in these pursuits he was an outspoken conservationist and advocate of strong, well-enforced laws for the protection of game and other animals. He characteristically led attempts to convince the legislature to end the confusing array of local statutes which he saw as working to the disadvantage of North Carolina's wildlife. It was not surprising, therefore, that he and T. Gilbert Pearson, founder of the National Association of Audubon Societies, were close, lifelong friends. The two met shortly after Brimley became curator of the museum, when Pearson was just emerging as one of America's pre-eminent ornithologists and conservationists. Judging from their correspondence they took particular delight in treating each other irreverently, and H.H. often sardonically addressed Pearson as "My Dear Boy."

In the early 1900s Pearson and the Brimleys collaborated on a major project, compiling data for and writing one of the first state bird books ever produced in the south—*Birds of North Carolina*. The first edition of this pioneer work, printed and ready for binding in 1913, was destroyed by fire in the printer's plant and the whole edition was lost before official publication. It finally appeared, with additional notes, in April 1919, published by the N.C. Geological and Economic Survey and profusely illustrated by Rex Brasher, Robert Bruce Horsfall, and Roger Tory Peterson. A second edition, published by the State Museum in 1942, quickly sold out. The third and final edition, revised by David L. Wray of the department's entomology division, and Harry T. Davis, the museum's second director, was published by the museum in 1959.

H.H. Brimley retired as director of the State Museum in 1937. As his replacement agriculture Commissioner W. Kerr Scott appointed Harry T. Davis, who had joined the staff in July 1920 as assistant curator and curator of geology. H.H. remained in the museum's employ as senior curator of zoology and stayed active until his death. During this period he did a great deal of work on the revised second edition of the bird book, published several scientific papers, and made two of his finest fish mounts (a 75-pound Channel bass and a 594-pound Blue marlin, then records for the east).

At the turn of the twentieth century, while exciting developments were occurring in the museum, a significant project was slowly and laboriously unfolding in another division of the Department of Agriculture. It added the vast realm of invertebrates, especially insects, to the fauna under study within the department, and involved C.S. Brimley nearly two decades before he became a state employee. Franklin Sherman, Jr. joined the Division of Entomology, and became North Carolina's first state entomologist in 1900. In addition to his duties in economic or applied

entomology, he began at once to collect and catalogue the insects and other arthropods of the state. One of his major purposes was to have a collection which would "give as complete an idea as possible of the insect life of the State, showing the different stages of growth of each species, and the food upon which they live." By the time of Sherman's 1902 report the collection had grown to "30,000 specimens, which may be seen at any time in the office of the Museum building."

Early in the century Sherman began publishing information accumulated in the project, and by the end of the first decade had produced lists of North Carolina tiger beetles, tabanid flies, flat bugs, butterflies, scorpionflies, dragonflies, and grasshoppers and their relatives. Many ofthese papers were coauthored with C.S. Brimley while he was still a private entrepreneur. C.S. met Sherman about the time he became state entomologist, and Sherman, as C.S. later wrote, "revived my long flagging interest in insects." Their association developed into a lasting friendship, and in December 1919 C.S. entered the service of the Division of Entomology to take charge of the "Insect Survey." By this time data had accumulated on more than 5000 species known to occur in North Carolina, and Sherman and his group had prepared several hundred pages of manuscript "for what we hope may ultimately be a volume on 'The Insects of North Carolina,' in which every known species of insect in the State shall be listed."

C.S. Brimley assiduously set about the task of expanding the collections and data files and enlarged their scope to include other members of the state's fauna. "When Mr. Brimley came into the state service," wrote Sherman in 1925, "he soon likewise card-catalogued the species of Batrachians, Reptiles, and Mammals of the state which have been recorded in papers by himself or others. With the Vertebrates thus on record, and the Insects in full swing, it was merely an incident to include the Invertebrates other than Insects." In addition to Sherman and Brimley, other workers on the "Insect Survey" through 1925 were J.C. Crawford, R.W. Leiby, C.L. Metcalf, Z.P. Metcalf, T.B. Mitchell, and M.R. Smith.

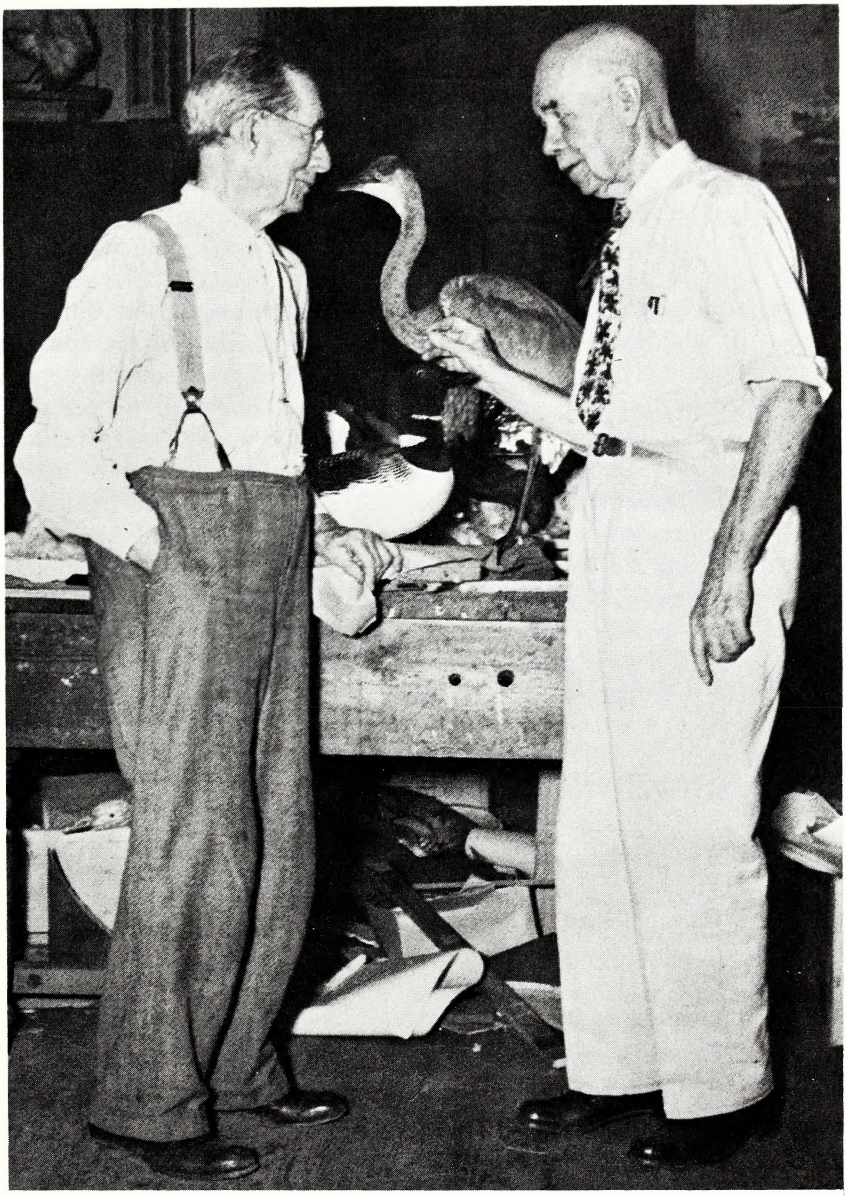
In most respects C.S. was the more scientifically oriented of the Brimley brothers and kept remarkably detailed records on southeastern fauna and flora for more than 60 years. By the time he joined the department he was already widely published in a number of journals, and his amazing expertise, largely self-taught, extended to entomology, herpetology, mammalogy, ornithology, and botany. He was also quite knowledgeable about many invertebrate groups other than insects. In short, he was a virtuoso naturalist, whose "main interest for many years zoologically," as he wrote in 1925, "has been to gain and disseminate

knowledge about the fauna of North Carolina, both vertebrates and invertebrates, with especial regard to Herpetology and Entomology, an interest very largely inspired and stimulated by Mr. Sherman."

C.S. Brimley's first publications were a number of ornithological notes on which he appeared as junior author with his older brother, starting with "Notes from middle North Carolina" in the October 1884 issue of *Ornithologist and Oölogist*. From then through 1894 he published another 70 brief solo notes, most of them in this same publication (which became defunct in 1893), and a few in the *Auk*. He became active in herpetology around 1890 and said that he was greatly helped by David Starr Jordan's *Manual of Vertebrates*, which for a number of years was his "vertebrate 'Bible'." His first non-ornithological publication apparently was the 1895 "List of snakes observed at Raleigh, N.C.," in the *American Naturalist*. During the next few years he published papers on amphibians, fishes, and larval insects, more on reptiles and birds, lists of mammals of Raleigh and of Bertie County, and a 32-page descriptive catalogue of the mammals of the state. He also collaborated with Sherman on many of the insect lists.

As his notebooks on file in the State Museum archives show, C.S. kept painstaking and meticulous records of all bird movements that occurred in his vicinity. He published several summary papers on this subject, including the 1917 "Thirty-two years of bird migration at Raleigh, North Carolina," in the *Auk*. On December 1, 1930 he was awarded a certificate from the Biological Survey, U.S. Department of Agriculture, in recognition of his 46 years of bird migration studies from 1885 to 1930. The earlier records provided much of the migration data for *Birds of North Carolina*.

In the course of his studies of the southeastern herpetofauna, C.S. Brimley described several new species and subspecies. The first of these were two salamanders named in 1912—*Plethodon metcalfi*, after another pioneer North Carolina scientist and co-worker Z.P. Metcalf, and the subspecies *Spelerpes* (now *Pseudotriton*) *ruber schencki*, for C.A. Schenck, director of the Biltmore Forest School. In 1924 C.S. recognized the endemic waterdog (an aquatic salamander) of the Neuse and Tar rivers as a distinct subspecies, *Necturus maculosus lewisi*, naming it for Frank B. Lewis who provided most of his specimens. A South Carolina salamander, *Plethodon clemsonae*, followed in 1927, and two turtles in 1928—*Pseudemys* (now *Chrysemys*) *vioscana* from Louisiana, named for the naturalist Percy Viosca, Jr., and the subspecies *P. concinna elonae* from a pond in Guilford County not far from Elon College. However, only two of his new forms have stood the test of time and further taxonomic studies. *Necturus lewisi* was elevated to full species status in 1937 by Viosca, and *Pseudotriton ruber schencki* is still recognized as a valid subspecies by some authorities



C. S. Brimley (left) and H. H. Brimley (right) in the basement preparation shop of the State Museum around 1944.

although questioned by others. As would be expected C.S. also described many insect species, primarily in the orders hymenoptera and diptera. These included 13 psammocharid and 5 sphecid wasps, one each of stratiomyid, cyrtid, conopid, sarcophagid and ortalid flies, and 4 asilid, 3 syrphid and 2 sciomyzid flies.

C.S. was a prolific writer who, before his career ended, published well over 150 papers, notes and booklets on vertebrates, over 40 on invertebrates, a 17-page paper on zoogeography, a partial bibliography of North Carolina zoology, many popular natural history articles and accounts, and a group of outlines for zoology lectures at the Biltmore School. In addition to coauthoring the bird book with Pearson and his brother, he wrote *The Insects of North Carolina,* which grew out of the early manuscript begun by Sherman and others and included 35 years of records on 9611 species. It was published in 1938 by the Department of Agriculture. He also compiled the first supplement to this work, published in 1942. A major summary of the amphibians and reptiles of North Carolina, originally published as an annotated and illustrated series in *Carolina Tips* from 1939 through 1943, was printed as a compilation by Carolina Biological Supply Company in 1944. A similar collection of North Carolina mammal accounts, written between 1944 and 1946, appeared in 1946. Two installments toward a comprehensive series on fishes of the state were published in the same outlet, but this project was interrupted by C.S.'s death.

His publications also included a 20-year history of the North Carolina Academy of Science. He and H.H. were founders of the Academy, and C.S. was the only person without a college degree to ever serve as its president. They were founders and life members, too, of the Raleigh Natural History Club, and helped organize the Raleigh Bird Club and the North Carolina Bird Club (now the two-state Carolina Bird Club).

In recognition of his outstanding contributions to the natural sciences, on June 7, 1938 the University of North Carolina conferred on C.S. Brimley the honorary degree of Doctor of Laws. This honor was all the more remarkable in light of the fact that, while far from unlettered, both the Brimley brothers were largely unschooled in any formal sense. H.H. spent eight years in the Bedford County School at Elstow, excelling in mathematics, football, and swimming, but left for a clerical job in Howard's Iron Works before receiving a certificate. C.S. was educated in the "common schools of Willington" until 1877, then attended the Bedford County School through the close of the second term in July 1880. "Attained the highest honors to be gained at that school," he wrote, "my education on leaving being equivalent at least to completing a high grade High School course or perhaps Freshman year in college." One writer,

W.T. Bost, later said that C.S. "had the sort of genius which made him a great scientist without asking anything of the schools." Then, in reference to his honorary doctorate, Bost added, "The University thinks it gave him a degree; but in a larger sense he gave it one."

H.H. Brimley died at Rex Hospital on April 4, 1946, age 85, probably the oldest active state employee in North Carolina's history. C.S. Brimley died at his home a little over three months later, on July 23, 1946, while dressing to go to his office in the Agriculture Building. Their productive careers were dedicated to the Department of Agriculture; H.H. was associated with the State Museum for over 60 years, 43 of them as director, and C.S. with the Division of Entomology for at least 45 years, nearly 27 of them as an employee. Their service to the state of North Carolina and its people, of course, cannot be measured in any such ordinary time frame. They had a very profound influence on the scientific and educational development of natural history in the southeast, particularly in their chosen state, perhaps more than any other naturalists of their time. The firm and enviable foundation which they laid was witnessed in a letter of April 12, 1946 to C.S. from a friend in Charlottesville, Virginia. "Both of you," he said, "have done a tremendous amount for the state in stimulating it to go ahead with various things. Virginia has no such museum, nor a collection of insects, nor such a bird book, or a catalogue of its mammals—and a lot of other things are lacking because Virginia had no Brimley brothers."

As a measure of the esteem in which these men were held by their colleagues and other specialists who came later and appreciated their contributions, a number of animals were named for them. These included the fish *Notropis brimleyi,* the frog *Pseudacris brimleyi*, the salamander *Desmognathus brimleyorum*, the millipeds *Deltotaria brimleii* and *D. brimleardia*, and the hymenoptera *Pedinaspis brimleyi, Halictus brimleyi, Colletes brimleyi,* and *Ephuta pauxilla brimleyi.*

Tributes to their influence on young naturalists, many of whom later became outstanding scientists, are numerous. One of America's leading ecologists, Eugene P. Odum (now Alumni Foundation Distinguished Professor of Zoology and director of the Institute of Ecology at the University of Georgia), wrote in the preface to his 1949 compilation of H.H.'s writings, 'I well remember my first visit with H.H. Brimley, when I was a young high-school student. He took me under his wing and made me feel at home immediately. The enthusiasm and sincerity with which he worked and talked impressed me especially. In fact, H.H. Brimley and his brother C.S. did more than anyone else to encourage me to develop my interest in birds which later led me to go into teaching and research in biology as a career."

A friend in England once wrote to H.H. Brimley: "But what a life you have had, and what an interesting one; it was built for you and fitted your

nature and inclinations; you must have reveled in it. It must have meant any amount of strenuous effort; but after all, that is the gist of life, and makes life worth living." These comments rather adequately summarized the lives of both these gifted men. They came here as immigrant lads from England and through diligence and dedication gave North Carolinians, and indeed in a larger sense all Americans, the great legacy of a wealth of knowledge about our natural heritage. This journal is dedicated to their memory.

ACKNOWLEDGMENTS.—I would like to thank Alexa C. Williams, John B. Funderburg, William M. Palmer, and Rowland M. Shelley, N.C. State Museum, and our former employee Sarah S. Robinson, for assistance in locating certain information; James F. Greene, Division of Pesticides and Plant protection, N.C. Department of Agriculture, for providing some of C.S. Brimley's notebooks; and Elaine H. Matthews, Public Relations Division, same department, for providing specific documents. Alexa C. Williams, Martha R. Cooper, and David S. Lee, all of the State Museum, made constructive criticisms of the manuscript, but any remaining atrocities are mine.

SOURCES.—Quotations whose specific sources are not identified in the text are from correspondence, unpublished manuscripts, and scripts and sketches of various kinds contained in the archives of the North Carolina State Museum of Natural History. The photographs are also from these archives. Some information on H.H. Brimley came from brief biographical sketches by Harry T. Davis (1946. J. Elisha Mitchell Sci. Soc. *62*:128-129) and C.S. Brimley (1946. Chat *10*:42-43). Developments in the Department of Agriculture were obtained from biennial reports of the Board of Agriculture and the commissioner of agriculture published in Raleigh. Franklin Sherman's comments anent the Insect Survey are from biennial reports and from "Progress on State Insect Survey with comparative data on other animal groups" (1925. J. Elisha Mitchell Sci. Soc. *41*:129-134). The comments by W.T. Bost are from the *Greensboro Daily News*, 27 July 1946. Information on Commissioner Polk mostly came from Stuart Noblin's two-part article, "Leonidas Lafayette Polk and the North Carolina Department of Agriculture" (1943. N.C. Historical Review *XX*:103-121, 197-218). Some of H.H. Brimley's writings, including verse, were compiled and annotated by E.P. Odum (1949. *A North Carolina Naturalist, H.H. Brimley*. Univ. North Carolina Press, Chapel Hill). Additional information on the Brimley brothers is contained in a history of the Department of Agriculture's involvement in natural history studies prepared by John B. Funderburg and me (in manuscript).

Accepted 19 December 1978

Nest and Larvae of the Neuse River Waterdog, *Necturus lewisi* (Brimley) (Amphibia: Proteidae)

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ABSTRACT. — The first reported nest and hatchling larvae of *Necturus lewisi* were found in Little River (Neuse River drainage), Wake County, North Carolina, on 2 July 1978. Finding an adult male tagged for behavioral studies with ^{60}Co wires led to their discovery. The nest was under a flat, granite rock in 1.2 m of water at mid-river. Thirty-two empty egg capsules, and three containing larvae which shortly emerged, were attached to the underside of the rock. The male, found in a depression in the sand-gravel substrate directly beneath the eggs, was apparently in attendance. Autopsy revealed that the male was in good condition with an empty digestive tract. The presence of females of other *Necturus* species in or near nests has been reported, but no males have previously been verified in this situation. The hatchling larvae of *N. lewisi* and *N. maculosus* are alike in color and pattern. However, post-hatchling larvae of *N. lewisi* have a light mid-dorsum and dark sides, while those of *N. maculosus,* as figured and described in the literature, have a dark dorsum bordered on each side by a thin, light, dorsolateral line. *Necturus punctatus* larvae are uniformly gray dorsally and lack striping. The distinctive post-hatchling larva of *N. lewisi* lends added credence to its current recognition as a full species.

INTRODUCTION

Necturus lewisi is a species of waterdog endemic to the Tar and Neuse River drainages of North Carolina. Only one field study of this salamander has been conducted (Fedak 1971). No accounts have been published of its life history, and no descriptions of nesting, courtship and reproduction, or illustrations of larvae, have appeared. Adults and larvae are described in Bishop (1926, 1943), Brimley (1924), Cahn and Shumway (1926), Viosca (1937), and Hecht (1958), but the larva descriptions are varied and contradictory. This paper describes the first discovered nest and provides the first accurate descriptions and illustrations of *N. lewisi* hatchlings and older larvae.

MATERIALS AND METHODS

In November 1977 we began a preliminary study of *N. lewisi* in the Little River, a tributary of the Neuse River in northeastern Wake County.

One purpose was to develop methods of following movements, determining home range, and studying other behavior using radioactive tagging and tracking techniques. Three adults (two females and a male) were trapped in wire and plastic mesh minnow traps at that time, and each was tagged with two ^{60} Co (35-50 mc) wires injected into the tail muscles using methods described by Barbour et al. (1969).

We initially used a Thyac III Model 491 survey meter and scintillation probe to locate animals, but monitoring proved difficult until a more sensitive submersible Model 498 probe was obtained later in the study. The tagged salamanders, which we had not located for three months, were easily detected with this instrument. The nest was discovered in July 1978 while we were checking the location of the tagged male. Three larvae were collected as they hatched from eggs, and four others were captured by dip netting within 5 m of the nest site.

Larvae were preserved in 8 percent buffered formalin within one hour after capture, and measurements, color observations and photographs made within two hours after preservation. Measurements, made with an ocular micrometer, are reported as snout-vent length (SV), measured midventrally from tip of snout to vent pore; total length (TL); head length (HL), from tip of snout to gular fold; head width (HW), at posterior edge of eye socket; and tail width (TW), at widest point.

All specimens obtained in this study are deposited in the lower vertebrate collections of the North Carolina State Museum of Natural History (NCSM). Additional post-hatchling larvae and subadults from various localities in both drainages were loaned by Duke University.

RESULTS

Nest. — On 2 July 1978 a nest and attending male (NCSM 19826; 147.6 mm SV) were found under a flat, granite rock (36 × 27 × 5.5 cm) in 1.2 m of water near midstream, approximately 2 m from shore. The underlying substrate was sand and fine gravel. Thirty-five egg capsules, 8-9 mm in diameter and each attached by a blunt stalk, were in an area of about 60 cm^2 on the underside of the rock. The rock's entire undersurface was devoid of sessile and other invertebrates and debris. A depression in the substrate, slightly larger than the nest area and about 40 mm deep, apparently had been made and maintained by the male. The depression narrowed and opened at the downstream edge of the rock, the upper edge of which was embedded in the substrate. Water flow at the time was slow, but this area is exposed to strong currents during flooding.

The male made no attempt to leave the nest until the rock was removed. It was collected, preserved within two hours of capture, and autopsied to verify sex and to determine general condition and any ob-

vious effects of the radioactive tags. Prior to preservation the animal was quite active and appeared healthy. Dissection revealed that the upper and lower sections of the digestive tract were empty, indicating that the animal had not eaten recently. The liver appeared normal (compared with other preserved specimens of similar size). The gall bladder was filled with bile. Although no fat was evident the animal was not emaciated. There was no indication of damage or irritation to muscle and skin tissue from the tags.

Thirty-two of the 35 egg capsules found were empty, but three were in the process of hatching and the larvae appeared within one hour. Although we netted for approximately 5 m around the nest, only four additional larvae were collected, all within one meter of the nest site. Large rocks and gravel reduced netting efficiency.

Hatchlings (Fig. 1). — The mean total length of seven newly hatched larvae is 22.8 mm (Table 1). The rounded head is totally unlike the squared, elongate head of the adult and ranged from 3.5 to 3.7 mm ($\bar{x}$ = 3.5) long and 3.0 to 3.1 mm ($\bar{x}$ = 3.0) wide. The eyes are dark and appear to be well formed. The forelegs are well developed, 2.0 to 2.2 mm long, with the three outermost toes complete and the inner toe budlike. The hind legs average 1.5 mm in length, are poorly developed, and are adpressed to the lower tail fin. The tail is finned dorsally and ventrally, with the dorsal fin slightly higher than the ventral and barely present at the tail tip. Tail width in the series ranges from 2.9 to 3.2 mm ($\bar{x}$ = 3.0). Because of the yolk sac the lower body is approximately 25 percent wider than the upper body. The head and dorsum are rather uniform light brown, and the color extends onto the area of the tail musculature. A dark line extends from the nostril through the eye to the gills. Behind each eye and above the dark line is a white, apparently rough, patch, equal to or slightly smaller than the eye. The dorsal melanophores stop abruptly on the side along a line level with the front and rear legs. Scattered melanophores are present on the gills, upper surfaces of the legs, lower jaw, and ventrolateral margins of the head. Melanophore concentrations are greatest in the area of the tail musculature, making the tail slightly darker than the head and truck. The ventral tail fin is unpigmented, while the dorsal tail fin is clear on the margin with melanophores increasing in number toward the musculature.

Post-hatchling larvae. — Color patterns were observed in 61 preserved *N. lewisi* larvae from the Tar and Neuse drainages and in one live specimen from the Neuse. Accurate description of some was difficult because of varying degrees of fading. However, 48 percent of all specimens (N = 28) between 21 and 41 mm SV have a distinct dark lateral stripe on each side, and 37 percent have a light dorsum with the dark sides not well defined

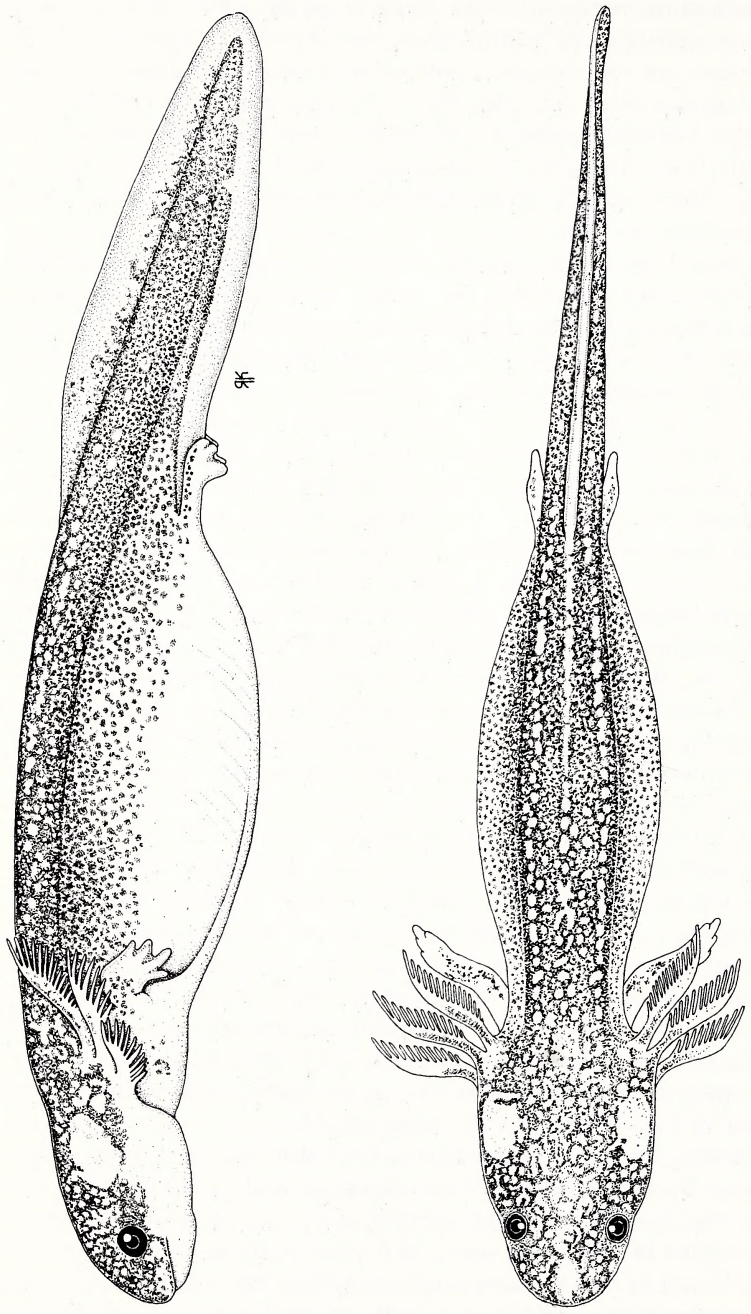

Fig. 1. Hatchling *Necturus lewisi* (NCSM 19827, lot); 20.7 mm TL (in preservative).

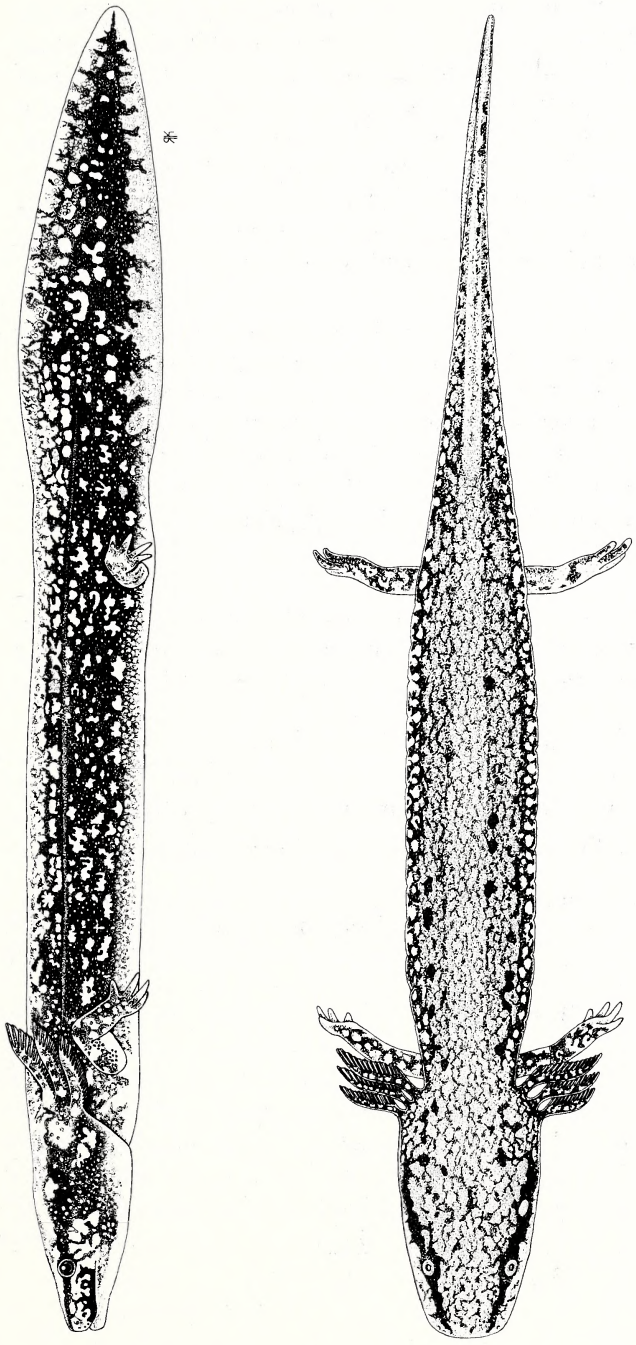

Fig. 2. Post-hatchling (striped) larva of *Necturus lewisi* (NCSM 16555); 42 mm SV, 65 mm TL (in preservative).

(Fig. 2). These larvae also have a broad, light tan, dorsal stripe which edges the costal grooves and extends from the snout onto the dorsum of the tail and across its width. The dorsal region may have a scattering of small, poorly defined, dark spots. The dark lateral stripe is continuous from the nostrils through the eye and labial region to the tail where it widens and includes all but the tail fringes. Irregular light blotches which lack melanophores are scattered throughout the costal and tail region. Most of the tail fin is lightly pigmented, but its edges lack pigmentation, as does the tip of the tail. The underside is white or has a faint, reticulated pattern.

A larva, maintained alive for one year, measured approximately 30 mm SV at capture and had a striped pattern which changed when it reached 45 mm SV. The lateral melanophores decreased in intensity while the dorsal spots became darker and better defined. Sixty-three percent of the preserved specimens (N = 33) between 45 and 72 mm SV show a similar loss of striped pattern with a distinct increase in dorsal spotting. All animals over 63 mm SV have an adult dorsal pattern.

DISCUSSION

The *N. lewisi* nest resembled reported stream nests of other *Necturus* species in construction, location, and general conditions. The number of eggs was greater than the 15 to 20 reported by Bishop (1943) for stream nests of *N. maculosus*, but within the range of 22 to 49 reported by Shoop (1965) for *N. m. louisianensis*.

Although Bishop (1943) and others verified females near or attending nests, few adults actually have been found in this situation. Most observers appear only to have surmised that nests are attended by females. Our

TABLE 1. Measurements (mm) of 7 newly hatched *Necturus lewisi* (NCSM 19827, lot). SV = snout-vent length; TL = total length; TW = tail width; HL = head length; HW = head width.

	SV	TL	TW	HL	HW
	15.3	22.8	3.0	3.5	3.0
	15.5	23.6	3.2	3.7	3.0
	16.3	23.0	2.9	*	*
	15.5	23.1	3.0	3.5	3.1
	15.0	22.2	3.0	3.5	3.0
	15.9	23.4	2.0	3.5	3.1
	14.9	21.8	3.1	3.6	3.0
$\bar{x}$ =	15.4	22.8	3.0	3.5	3.0

*damaged in capture

deduction that the male present in the nest was attending it and not preying on hatchlings is based on the absence of larvae from the digestive tract and the reluctance of the male to leave the nest. Broader studies which we are now conducting on *N. lewisi* may provide evidence to corroborate this observation.

Brimley (1924) stated, "Young specimens of the northern form (*N. maculosus*) are said to be striped with black, but the smallest of ours that I have seen (measuring only about 3½ inches in length) was spotted exactly like larger specimens. In view of these facts it would seem fairly apparent that the dwarf form occurring at Raleigh is a geographical variant of subspecies of the true *maculosus*, and I propose for it the name *Necturus maculosus lewisi* . . ." A similar description of the larva was given by Hecht (1958). Viosca (1937) elevated *N. m. lewisi* to full species status and stated that 55 mm larvae were dark on the sides and had a light dorsum marked with faint spots. He also indicated that these spots develop into two or three irregular rows as the larvae approach 90 mm, at which length all striping disappears and they attain the adult spotted appearance. We assume that Viosca's measurements were total lengths, although this was not indicated. If so, his observations compare favorably with ours of live and preserved post-hatchling larvae, confirming that such larvae are quite distinct from those of *N. maculosus* as illustrated by Bishop (1943), and *N. m. louisianensis* as described by Shoop (1965).

The major difference is that *N. maculosus* post-hatchling larvae have a dark dorsum bordered on each side by a thin, light, dorsolateral stripe. However, newly hatched larvae of both species are indistinguishable from each other. The larvae of *Necturus punctatus*, a species largely sympatric with *N. lewisi* although occupying a broader range, are uniformly gray in color with no evident striping (Brimley 1925, Bishop 1943). The distinctive post-hatchling larva of *N. lewisi* lends added credence to its current recognition as a full species.

ACKNOWLEDGMENTS. — We wish to express our appreciation to John C. Clamp, Patricia S. Ashton and John E. Cooper, North Carolina State Museum, for their assistance in the field and their reviews of this manuscript; Renaldo Kuhler, North Carolina State Musuem, for his skill in illustrating the larvae; and Joseph R. Bailey, Duke University, for loan of specimens. This study was partly supported by a grant from the Carolina Conservationist program of the N.C. Wildlife Resources Commission.

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Accepted 14 December 1978

A New Species of *Xironodrilus* Ellis 1918 from North Carolina (Clitellata: Branchiobdellida)

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ABSTRACT. — *Xironodrilus bashaviae*, new species, is described from the crayfish *Cambarus bartonii* collected at several sites in the upper drainage of the Yadkin River, Forsyth County, North Carolina. It is the only species of the genus known to occur east of the Blue Ridge Mountains. The new species differs from other members of the genus primarily in details of the reproductive system and dental formula.

None of the known species of the genus *Xironodrilus* Ellis 1918 has been adequately described in published work. The discovery of a new species outside the recorded range of the genus (Holt 1969) and the work of one of us (W.) on the ultrastructure of this form affords us a propitious opportunity to present a description of this newly found species.

The literature pertaining to *Xironodrilus* is exceedingly sparse. Moore (1894) recognized as *Branchiobdella pulcherrima* the first species now assigned to the genus. Ellis (1919) formally erected the genus and more fully described a species, *X. formosus*, which had been proposed in an earlier paper (Ellis 1918). The effective date for both the erection of the genus and the naming of its type-species (*X. formosus*) must derive from this earlier work. There are other incidental references and some incomplete, but valid, species designations in the literature which will be cited below, but the only detailed treatment of the genus is contained in Holt's (1951) unpublished dissertation.

Our methods are those long used by Holt (1960 *et seq.*). Serial sections were prepared by Weigl using material fixed in 70% ethanol and stained with Harris' hematoxylin and eosin. The drawings (by H.) were done with the aid of a camera lucida; all structures are illustrated with their anterior

to the reader's right; cross-hatching indicates muscular and stippling, primarily, glandular tissues. Measurements are approximations done with an ocular micrometer and where averages are given the minimal and maximal measurements taken are enclosed in parentheses. The scanning electron micrograph was photographed by Weigl.

Genus *Xironodrilus* Ellis 1918

Type-species: — *Xironodrilus formosus* Ellis 1918, by subsequent designation (Ellis 1919).

Diagnosis: — Body depressed widening gradually from segment I to segment VII; deferent ducts entering ental end of spermiducal gland; prostate absent; bursa spherical; penis protrusible (modified from Hobbs et al. 1967).

Remarks: — Members of the genus are distinguished from those of *Xironogiton* Ellis 1919, and *Ankyrodrilus* Holt 1965, the only other American branchiobdellids with a flattened ("depressed") body form, by the ental entry of the vasa deferentia into the spermiducal gland. The species of *Xironodrilus* are known from the Blue Ridge Province of the Appalachians and the Interior Low Plateaus into the glaciated regions of Michigan (Holt 1969): the species described herein is the only one known from the Piedmont of the Appalachians east of the Blue Ridge Mountains.

Xironodrilus bashaviae, new species
Figures 1 and 2

Type-specimens: — Holotype, USNM 53641 taken on *Cambarus bartonii* from Hunter's Creek, 0.8 km from the intersection of State Routes 1463 and 1446, Forsyth County, North Carolina, by Ann M. Weigl, 9 September 1975 (PCH 3376; AW 21 A); three paratypes (PCH 3376) in the VPI & SU Center for Systematics Collections; three paratypes (AW 21 C) in the collections of Ann Weigl.

Diagnosis: — Medium large branchiobdellids (average length about 3.5 mm); dental formula 4/4, lateral teeth of each jaw longer than median ones; bursa subspherical; ejaculatory duct long, thick, curving laterodorsad from bursa; spermiducal gland large, with prominent lumen; spermathecal duct long, bulb long, subcylindrical.

Etymology: — For Bashavia Creek, of which Hunter's Creek is a tributary.

Description: — Specimens of *Xironodrilus bashaviae* are large, but not among the largest, branchiobdellids, averaging about 3.5 mm in length (pre-

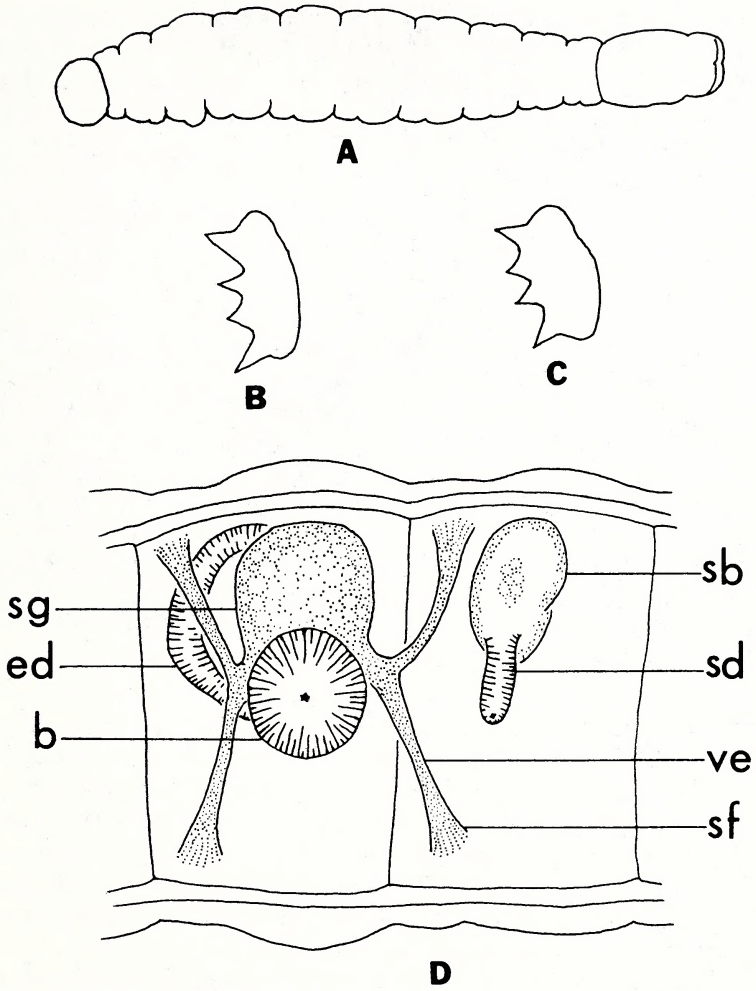

Fig. 1. Structural details of *Xironodrilus bashaviae* new species. A, ventral view of holotype; B, upper jaw; C, lower jaw of paratype; D, reproductive systems in ventral view. Abbreviations: *b*, bursa; *ed*, ejaculatory duct; *sb*, spermathecal bulb; *sd*, spermathecal ectal duct; *sf*, sperm funnel; *sg*, spermiducal gland; *ve*, vas efferens.

served material). The holotype (selected for the clarity with which internal structures may be seen) has the following dimensions: *total length*, 2.8 mm; *greatest diameter*, 0.6 mm; *head length*, 0.6 mm; *head diameter*, 0.4 mm; *diameter, segment I*, 0.3 mm; *diameter, sucker*, 0.4 mm. The average dimensions, with minima and maxima given in parentheses, of the holotype and four specimens selected at random from the type-series are as follows: *total*

Fig. 2. Scanning electron micrograph of a portion of the body of *X. bashaviae*. Note ciliary tufts.

length, 3.4 mm (3.4-4.2 mm); *greatest diameter*, 0.8 mm (0.6-1.2mm); *head length*, 0.7 mm (0.6-0.8 mm); *head diameter*, 0.5 mm (0.4-0.6 mm); *diameter, segment I*, 0.4 mm (0.3-0.5 mm); *diameter, sucker*, 0.5 mm (0.4-0.5 mm). In the holotype and one paratype, segment V was greater in diameter than segment VII. The latter, which bears the ovaries and developing eggs, is normally greater in diameter among all members of the order. In these two specimens there are no large eggs.

Scanning and transmission electron microscopy of *X. bashaviae* have revealed the presence on the outer epithelium of numerous bristle-like structures, each composed of a tuft of cilia. The tufts are most abundant in the region of the mouth, but are also found on other parts of the head as well as on the body segments (Fig. 2). They are not visible by light microscopy, though "sensory" hairs have been detected in the mouth region of other branchiobdellids (Franzen 1963:370; Moore 1895:499; Holt, unpub. observ.).

The animals widen uniformly from segment I to their greatest diameter in segments VI and VII and from there become narrower towards the sucker and are uniformly, but not excessively, flattened, except for the terete head. The posterior annulus of each segment is only slightly less in

diameter than the anterior one, conferring a generally smooth appearance to the outline of the body.

There is a pronounced external sulcus or constriction of the head immediately posterior to the position of the jaws. No other external evidence of the segmentation of the head is apparent. Both upper and lower lips bear very shallow and narrow emarginations. Oral papillae are not detectable in our specimens. There is one internal pharyngeal sulcus, deep, and closely compressed, delimiting the posterior 1/3 of the head region from the anterior 2/3.

The jaws are subequal in size, their width about 1/8 the greatest diameter of the head. They consist of subquadrangular plates carrying prominent teeth-bearing ridges. The dental formula is 4/4 and the lateral teeth are longer than the median ones and often noticeably diverge laterad. The teeth may be blunted, particularly the median ones, presumably by wear. The jaws are brown; the teeth colorless.

The sperm funnels are narrow; not conspicuously set off from the vasa efferentia by constrictions. The vasa deferentia are short and thick, entering the ental borders of the spermiducal gland at widely separated portions of its ventral surface.

The spermiducal gland is short and thick and roughly subspherical. Its ventral (ental) border lies just dorsal and to the side of the bursa; its dorsal border extends to about the mid-portion of its segment. Its most distinctive feature, aside from shape, is the capaciousness of its lumen (obscure in most branchiobdellids) which is expanded so that it appears as a thin-walled sac filled with a clear fluid. Moreover, again unusual, there are small amounts of spermatozoa clustered in the central portion. The wall of the spermiducal gland is, however, composed of the usual elements (Holt 1949) of a peritoneal investiture, a thin muscular covering and a lining of glandular epithelium.

The ejaculatory duct is a long and prominent tube composed of the usual layers of muscle. The bursa is small and subspherical, in diameter about 3/4 that of the segment (VI) in which it lies. There is a short ectal (outlet), narrowed portion and the penis is a simple, protrusible, muscular cone, exserted, one presumes, by the eversion of the bursa.

The spermatheca has a relatively long ectal duct and the cylindrical bulb bends dorsad between the gut and the body wall. The curvature of the organ precludes, in the absence of tedious and essentially impossible procedures, any just estimate of its length.

Variation: — Beyond the usual differences in size and those produced by differing degrees of contraction at death, there are few variations of note. The relative lengths of the teeth seem to differ, but the lateral teeth are

always at least as long as the median ones and usually longer. There is a possibility that the dental formula may vary slightly, but it is constant for all the specimens examined in which it could be determined.

Affinities: — In the true sense of the word, until there is a monographic revision of the genus, the affinities of *X. bashaviae* cannot be determined. *Xironodrilus formosus* has a small spermiducal gland without the expanded lumen of *X bashaviae* and lacks an ejaculatory duct. The dental formulas also differ: that of *X. formosus* varies from 4/3 to 6/5 (Holt 1951). *Xironodrilus pulcherrimus* (Moore 1894) has a dental formula of 3/3 with the middle tooth shorter than the lateral ones and its spermiducal gland is slender and lacks the expanded lumen of *X. bashaviae*. In addition, specimens of *X. pulcherrimus* (Moore 1894; Holt 1951) are somewhat larger than any of those of *X. bashaviae* we have measured. *Xironodrilus appalachius* Goodnight 1943 also has a dental formula of 3/3 with the middle tooth longer than the lateral ones and a reproductive system similar to that of *X. pulcherrimus*. Specimens of *X. appalachius* are of approximately the same size as those of *X. bashaviae* (Holt 1951). *Xironodrilus dentatus* Goodnight 1940 is characterized by a dental formula of 4/5, 5/5 or 5/4 and is recorded from Oklahoma and Missouri. The jaw shape and other features of this species also differ from *X. bashaviae* (Holt, unpub. data).

Host: — *Cambarus bartonii* (Fabricius 1798).

Distribution: — The type-locality, two sites in Bashavia Creek and one in Fries Creek, are all part of the upper drainage of the Yadkin River in Forsyth County, North Carolina.

Material examined: — The type-series and 38 other specimens mounted entire and portions of several serially sectioned animals.

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Accepted 14 November 1798

A New Cryptic Species of Salamander of the Genus *Plethodon* from the Southeastern United States (Amphibia: Plethodontidae)

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ABSTRACT. — A new species of woodland salamander, *Plethodon websteri*, is described. It is a member of the *P. welleri* group of eastern small plethodons and is morphologically very similar to *P. dorsalis*, but differs from it at over 80% of 26 genetic loci as determined by electrophoresis. This represents an extreme case of genetic divergence without accompanying morphological change. The geographic range of *P. websteri* includes east central Alabama and west central Georgia with disjunct populations in Clarke County, Alabama; Winston County, Mississippi; and McCormick County, South Carolina. The ranges of *P. dorsalis* and *P. websteri* are largely allopatric, but the two have been found sympatrically at one locality in Jefferson County, Alabama.

An electrophoretic study of genetic variation in salamanders of the *Plethodon welleri* group (Larson and Highton 1978) showed that an undescribed species occurs in Mississippi, Alabama, Georgia and South Carolina. Morphologically it is so similar to *Plethodon dorsalis* Cope that there are no known standard taxonomic characters that distinguish the two species. Yet genetically they are so different that they share less than 20% of their alleles at the 26 genetic loci evaluated electrophoretically. Thus they represent a most extraordinary example of evolutionary genetic divergence without accompanying morphological change.

There is no doubt of the specific distinctness of the two species. They differ genetically from each other more than do some genera, for example *Notophthalmus* and *Taricha* (Ayala 1975). They have been taken sympatrically in Jefferson County, Alabama, and no electrophoretic hybrids were detected. The absence of diagnostic morphological characters requires that the species be diagnosed exclusively on the basis of electrophoretically detectable differences in the mobility of protein molecules. This makes it difficult to identify living or preserved salamanders. Fortunately, the ranges of the two species appear to be largely allopatric so that most individuals may be identified on the basis of geographic provenance. Moreover, in and near the zone of contact between the two

species, there is character displacement in color morph frequency, so that even in the zone of sympatry all available specimens that have been examined electrophoretically may be correctly allocated to species on the basis of color morph.

I name the new species for my friend, the late T. Preston Webster, who first called my attention to the remarkable amount of electrophoretic divergence found in southern populations of *Plethodon dorsalis* representing the new species.

Plethodon websteri, new species

Diagnosis: — An eastern small *Plethodon* of the *P. welleri* group (Highton 1962) that has virtually the same range of variation as *P. dorsalis* for all known morphological taxonomic characters, but that differs from *P. dorsalis* at most genetic loci evaluated electrophoretically. All samples of the two species are completely separable (they do not share a single common allele) at 14 of 26 genetic loci (Larson and Highton 1978): fumarase, glutamic oxaloacetic transaminase-1, indophenol oxidase-1, indophenol oxidase-2, heart lactate dehydrogenase, muscle lactate dehydrogenase, leucine aminopeptidase, malate dehydrogenase-1, malate dehydrogenase-2, peptidase-2, transferrin, and general proteins B, C and D. Most populations of the two species also are distinct at 6 additional loci: esterase, isocitrate dehydrogenase-1, isocitrate dehydrogenase-2, phosphoglucomutase, phosphoglucose isomerase and general protein A. Good diagnostic loci are fumarase, indophenol oxidase-1, indophenol oxidase-2, heart lactate dehydrogenase, malate dehydrogenase-2, and protein C (the polypeptides of *P. websteri* migrate cathodally to those of *P. dorsalis*) and leucine aminopeptidase, malate dehydrogenase-1, peptidase-2 and protein B (the polypeptides of *P. websteri* migrate anodally to those of *P. dorsalis*). *Plethodon websteri* differs from *P. welleri* in the same morphological ways as does *P. dorsalis* (it has modal number of 19 trunk vertebrae compared to 17 in *P. welleri*; its belly is heavily mottled with red, white and black chromatophores compared to the black belly with small white spotting of *P. welleri*; and there is color pattern dimorphism in *P. websteri*: a red or yellow striped dorsal pattern morph and a dark brown unstriped morph in *P. websteri* compared to an unstriped brown dorsal color pattern heavily mottled with brassy flecking in *P. welleri*). The electrophoretic data and their genetic analysis are presented in Larson and Highton (1978).

Holotype: — NMNH 204814, an adult male collected 0.6 km east, 0.9 km south of Howelton, Etowah County, Alabama, on 7 January 1976 by Scott Bunting, Richard Highton, Mark Kielek and Allan Larson.

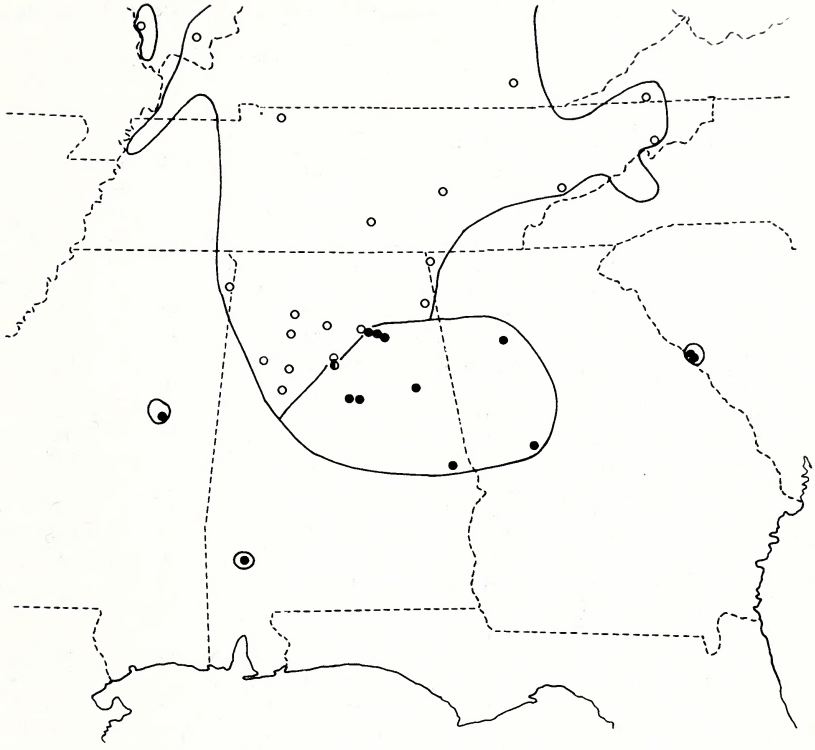

Fig. 1. Electrophoretic localities of *P. dorsalis* (hollow circles) and *P. websteri* (solid circles) in the southeastern United States. Approximate limits of the ranges of the two species are indicated. The locality in Jefferson County, Alabama where the two species are sympatric is indicated by a half solid circle.

Paratypes: — NMNH 204815-34, topotypes.

Other material: — Living individuals have been examined from all localities listed in table 1 and preserved specimens from most localities will be depositied in the collection of the National Museum of Natural History (NMNH).

Description of Holotype: — Before preservation, the length from the tip of the snout to the anterior angle of the vent was 39 mm, to the posterior angle of the vent 41 mm, and the total length 78 mm. There are 18 costal grooves (equivalent to 19 trunk vertebrae) and the vomerine teeth number 6 on each side. A red dorsal stripe with irregular edges was present in life; it is wider and brighter red on the tail than on the dorsum. The legs and sides were brown with abundant yellow and red spots and brassy flecks.

Table 1. Localities and number of *P. dorsalis* and *P. websteri* identified electrophoretically.

Species	*State*	*County*	*N*	*North Latitude* °	′	″	*West Longitude* °	′	″
P. dorsalis	Alabama	Blount	1	34	09	03	86	27	18
”	”	Cullman	1	34	10	22	86	53	31
”	”	DeKalb	3	34	23	38	85	37	38
”	”	Fayette	7	33	45	43	87	45	05
”	”	Jefferson	7	33	43	33	86	49	15
”	”	Jefferson	4	33	46	55	86	49	10
”	”	Lawrence	48	34	18	25	87	20	10
”	”	Tuscaloosa	2	33	26	38	87	29	47
”	”	Walker	7	33	42	20	87	23	22
”	”	Winston	3	34	03	30	87	20	45
”	Arkansas	Independence	23	35	52	30	91	46	26
”	”	Pope	16	35	38	28	93	04	03
”	”	Stone	45	35	59	05	92	16	02
”	Georgia	Dade	16	34	52	02	85	31	58
”	Illinois	Pope	61	37	22	54	88	40	20
”	”	Union	46	37	32	43	89	26	14
”	Indiana	Crawford	15	38	16	35	86	32	10
”	”	Parke	61	39	53	14	87	11	20
”	Kentucky	Franklin	55	38	11	24	84	52	53
”	”	McCreary	2	36	52	15	84	21	55
”	Mississippi	Tishomingo	15	34	36	23	88	10	32
”	Missouri	Taney	4	36	40	14	93	18	37
”	Oklahoma	Adair	21	35	50	13	94	39	20
”	”	Cherokee	1	35	58	03	94	48	55
”	”	Sequoyah	34	35	34	47	94	31	20
”	”	”	2	35	37	47	94	34	50
”	Tennessee	Bledsoe	32	35	38	32	85	19	55
”	”	Blount	9	35	38	20	83	44	51
”	”	”	36	35	39	56	83	47	04
”	”	Montgomery	34	36	31	00	87	30	35
”	”	Moore	7	35	20	55	86	20	30
”	”	Washington	6	36	10	32	82	31	17
”	Virginia	Scott	3	36	38	05	82	26	52
”	”	”	15	36	37	50	82	35	22
P. websteri	Alabama	Blount	17	34	05	12	86	20	57
”	”	”	7	34	08	03	86	23	09
”	”	Clarke	66	31	32	55	87	55	48
”	”	Cleburne	37	33	29	15	85	47	28
”	”	Etowah[1]	64	34	02	51	86	10	38
”	”	”	51	34	04	06	86	18	43
”	”	Jefferson	4	33	43	33	86	49	15
”	”	Lee	36	32	36	17	85	17	57
”	”	Shelby	9	33	21	37	86	28	38
”	”	”	1	33	22	03	86	39	49
”	Georgia	Cobb	28	33	58	34	84	34	56
”	”	Upson	91	32	47	38	84	15	30
”	Mississippi	Winston	30	33	09	10	89	02	50
”	South Carolina	McCormick	81	33	41	20	82	09	15
”	”	”	8	33	43	48	82	11	02

[1]Type locality of *P. websteri*.

The chin and belly had red, white, and black pigment in the following proportions: chin 50:40:10, belly 30:60:10. It is a mature male with a rounded mental gland as in *P. dorsalis* and *P. welleri* (Highton 1962:fig. 2D).

Distribution: — *P. websteri* is known from east central Alabama and west central Georgia. Apparently disjunct populations occur in Clarke County, Alabama, Winston County, Mississippi, and McCormick County, South Carolina (figure 1).

Variation in P. websteri: — The modal number of trunk vertebrae in all known populations of *P. dorsalis* is 19. This is also true for *P. websteri* with the exception of the two samples from McCormick County, South Carolina. Both have slightly more individuals with 20 trunk vertebrae than they do with 19 (mean = 19.6 in the more southern sample and 19.8 in the more northern sample).

As in *P. dorsalis*, most samples of *P. websteri* include salamanders of both the red striped and unstriped morphs, and individuals intermediate between the two. Because of the difficulty of classifying intermediate individuals, it is impossible to objectively quantify the data on the frequencies of the color morphs. This is in contrast to several other species of the genus in which few or no intermediates between the two color morphs occur. In spite of the difficulty in classifying a few individuals, most *P. websteri* from the immediate vicinity of the zone of contact between *P. websteri* and *P. dorsalis* in Blount and Etowah Counties, Alabama are of the red striped morph, while *P. dorsalis* from nearby Lawrence, Cullman and Blount Counties are of the unstriped morph. At the locality where the two species were taken sympatrically in Jefferson County, Alabama, 8 animals of each morph were collected. Of the 11 that were examined electrophoretically, all 4 *P. websteri* are of the striped morph and all 7 *P. dorsalis* are of the unstriped morph. No intermediates are present and no genetic hybrids were found. This same kind of character displacement in color morph frequencies has been reported for contact zones of several other pairs of species of eastern small *Plethodon* (Highton 1962, 1972).

Remarks: — A photograph of a living individual from Lee County, Alabama appears in Mount (1975:133) and is presumably *P. websteri* since the locality is within the range of the species.

Although the holotype of *P. websteri* has not been subjected to electrophoretic analysis, there is little doubt that it belongs to this species. Sixty-four other salamanders from the type locality have been studied electrophoretically and all are *P. websteri*.

Additional studies of the zone of contact and/or overlap of the ranges of the two species in Alabama are needed to determine the nature of their

geographic and ecological interactions as well as the details of the color morph character displacement in that area.

No morphological differences in standard taxonomic characters used to distinguish species group taxa in the genus *Plethodon* have been detected in this pair of sibling species, but this does not preclude the possibility that a multivariate morphometric analysis might detect differential characters. Such a study would be especially interesting because of the very large amount of genetic divergence between *P. dorsalis* and *P. websteri*.

ACKNOWLEDGMENTS. — I wish to thank all those persons who helped with the field work, including several who provided information on localities, as well as those who aided in the laboratory work, especially Allan Larson and the late T. Preston Webster. The work was supported by the National Science Foundation (grants DEB 76-10583 and GB-37320).

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Accepted 27 November 1978

The Female Reproductive Cycle in North Florida *Kinosternon baurii* (Testudines: Kinosternidae)

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ABSTRACT.—Female striped mud turtles are generally active throughout the year, with maximum activity in March and October and minimum in February and July. Females mature at an age of 5 to 6 years and a plastron length of 70 to 75 mm.

Vitellogenesis is continuous from July through the following May. Ovulation and oviposition occur from at least September to June. At least three clutches are produced annually. Egg size averages 28 × 17 mm and is not correlated with female size or clutch size. The mean length of laboratory incubation is 119 days and hatchlings average 19.2 mm PL. Clutch size ranges from one to five (usually two or three) and is positively correlated with female size. Each clutch comprises about 8 percent of total body weight.

INTRODUCTION

Few reproductive studies exist for mud turtles (genus *Kinosternon*) other than *Kinosternon subrubrum* (Mahmoud and Klicka 1972; Gibbons 1975; Iverson, 1979) and *Kinosternon flavescens* (Mahmoud and Klicka 1972; Christiansen and Dunham 1972). Studies by Sexton (1960) of *K. scorpioides* and by Moll and Legler (1971) of *K. leucostomum* comprise the only other detailed studies. Most *Kinosternon* reproductive information is anecdotal.

The present knowledge of reproduction in *K. baurii* is based almost entirely on Einem's (1956) and Lardie's (1975) observations in central Florida. The purpose of this report is to provide more complete information on the female reproductive cycle of striped mud turtles, *Kinosternon baurii* from northern Florida. This study, with others now in progress by this author, should soon permit an analysis of reproductive strategies within the genus.

MATERIALS AND METHODS

Female turtles were collected whenever possible in Alachua, Levy, and Marion counties in north Florida (usually within 50 km of Gainesville)

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from January 1972 through December 1976. Due to the proclivity of adults and hatchlings to terrestrial activity in north Florida (Carr 1952), this species is more frequently encountered on land than any other local turtle. Most turtles were collected as they attempted to cross roads. Many of these were dead on the road, but remained intact enough to provide suitable specimens for measurement and dissection. Turtles were also obtained by trapping, seining, and diving. In addition, specimens from north Florida in the Florida State Museum (University of Florida) collection were included in the samples.

Ovarian follicles, oviducal eggs, and corpora lutea were examined and measured in each specimen. All straight-line measurements were taken with dial calipers to the nearest 0.1 mm. Carapace length (CL) and plastron length (PL) were also recorded. Measurements from preserved turtles did not significantly differ from the data collected from fresh specimens and were included in the analysis.

Several clutches of shelled oviducal eggs were removed and incubated to hatching at 27° to 29°C. Data from eggs in natural nests were also recorded. Most turtles were deposited in the Florida State Museum, University of Florida, but a representative series was retained by the author. Means are followed by ± one standard deviation. All measurements are in mm.

SEASONAL ACTIVITY

Striped mud turtles were collected throughout the year, both on land and in water. Individuals may be found active on all but a few of the coldest winter days. This species thus exhibits the longest annual activity cycle of any previously studied kinosternid in the United States (Christiansen and Dunham 1972).

Annual terrestrial activity seems to be bimodal. Striped mud turtles are most frequently encountered (especially on land) in March when spring rains are filling the ponds and marshes, and in October as water levels are dropping. Few turtles were collected during late summer when water levels and temperatures are maximal, or in mid-winter (February) when temperatures are minimal. Wygoda (1976) found a similar annual activity pattern in *K. baurii* inhabiting seasonally flooded hardwood swamps in central Florida.

Since annual activity is bimodal, two (or more) epidermal scute annuli are often produced by an individual turtle during any one year. Winter annuli are apparently always produced and are usually more distinct than those produced in the summer. This variation in annuli production often makes aging turtles, based on scute annuli, difficult.

AGE, GROWTH, AND SIZE AT MATURITY

Females possessing ovarian follicles exceeding 7 mm diameter (or oviducal eggs or corpora lutea) during the months of July through May were considered mature. The three smallest mature females had plastral lengths of 69.4, 70.2 and 72.7. The four largest females judged to be immature measured 66.6, 67.9, 74.8, and 79.6 PL. Maturity therefore occurs at sizes between 70 and 75 PL (75 to 80 CL). I believe the 79.6 PL immature was reproductively anomalous since nine other females with plastron lengths between 75 and 80 mm were mature. The smallest mature female dissected by Einem (1956) was 81.2 mm CL and the largest immature female was 71.1 mm CL.

Age at maturity was estimated by counts of clearly visible winter (or primary) abdominal scute annuli as described by Sexton (1959). The oldest immature females bore six clear primary annuli (74.8 and 79.6 PL); the youngest mature female had only five (73.1 PL), indicating the usual age at maturity to be five or six years.

Plastron lengths calculated from the abdominal scute annuli lengths of 19 juvenile and young adults in the manner of Ernst et al. (1973) indicated turtles in their first winter averaged 17.9 PL (Range = 14.4-20.6, N = 19). Those in their second winter averaged 32.7 PL (25.5-39.0, N = 19); in their third winter, 45.7 (34.3-56.8, N = 14); fourth, 57.8 (49.3-64.3, N = 11); fifth, 68.9 (62.8-76.9, N = 9); sixth, 74.3 (69.1-82.0, N = 8); and in their seventh, 75.1 (71.1-83.8, N = 7). If turtles are maturing at plastral lengths of 70-75, these data support the contention that maturity occurs during the fifth to sixth years of age.

Average size of 101 adult females previously examined from throughout Florida (Iverson 1978b) was 86.2 PL (91.6 CL) [52 males averaged 73.1 PL, 83.7 CL]. The largest female measured 105.1 PL and 114.7 CL. The PL-body weight (in gm) regression, based on six females (69.1-90.0 mm PL, and 64.5-143.1 gm), is Wt = 3.36 PL - 154.84 ($r = 0.92$; $p<0.01$). From this regression the average female (86.2 PL) weighs 135.1 gm.

FEMALE REPRODUCTIVE CYCLE

The ovarian cycle is nearly continuous (Table 1), with only a short summer quiescent period (coincident with the summer reduction in activity). Ovulation occurs from late August or early September to early June. Based on excavated nests and the presence of oviducal eggs, females apparently nest from September through June. Females continue to yolk follicles to replace those ovulated during all but the last of this period. Follicular enlargement is curtailed only from late May through June. During the remainder of the year enlarged follicles (> 7 mm) are

typically found in the female reproductive tract along with oviducal eggs and/or corpora lutea.

Ova were removed from oviducal eggs to determine their approximate size at ovulation. Twenty-two excised yolk masses averaged 16.24±1.06 (Range = 14.5-18.0) in diameter. Maximum diameter of an ovarian follicle was 17.5. Only four females had ovarian follicles exceeding 16 mm in diameter.

The ovaries of one dissected female (98.8 PL), collected 22 April 1972, were anomalous in that her ovaries bore no corpora lutea or follicles > 4 mm in diameter.

Of 50 females with oviducal eggs and corpora lutea, 16 exhibited evidence of transuterine migration of ova. Net migration was away from the tract with the larger ovary in 11 (68.8%) of the cases, and probably served to equalize reproductive tract volumes.

The length of time that eggs were retained in the oviducts is not known. No females with oviducal eggs had the corresponding corpora lutea in any state of regression; all appeared fresh (maximum corpora lutea diameter is 6-7 mm). A physiological mechanism such as that suggested by Moll and Legler (1971) may allow female *K. baurii* to retain their eggs until suitable nesting sites and conditions can be found, without possibility of subsequent ovulation.

Table 1. Percentage of mature female *Kinosternon baurii* bearing enlarged follicles (> 7.0 mm), oviducal eggs, and corpora lutea for each month.

Month	Sample Size	% with Enlarged Follicles	% with Oviducal Eggs	% with Corpora lutea
January	9	100	77.8	100[a]
February	2	100	50	50
March	25	100	56	92
April	9	88.9	44.4	55.5[a]
May	15	73.3	53.3	73.3
June	7	57.1	28.6	42.9[a]
July	1	100	0	100
August	4	100	25	25
September	4	100	100	100
October	9	100	88.9	100[a]
November	3	100	100	100
December	7	100	100	100

[a]includes one female with two sets of corpora lutea.

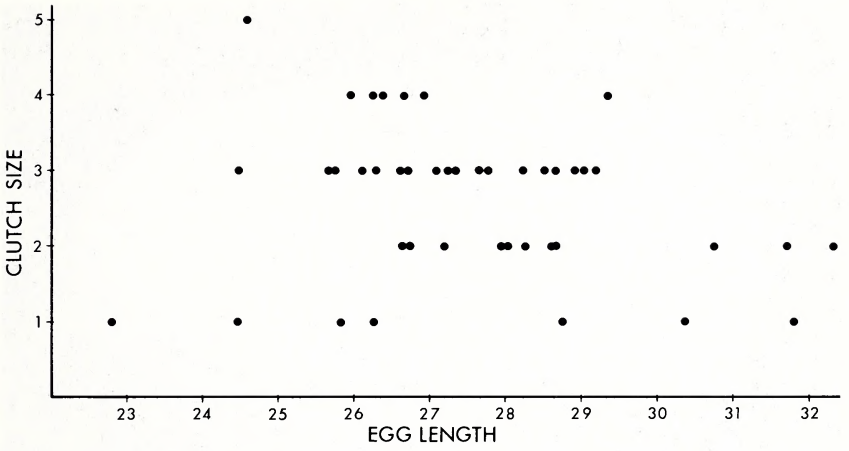

Fig. 1. Relationship between clutch size and egg size (mean length for clutch in mm) in *Kinosternon baurii*. Each symbol represents at least one record. Least squares regression is $y = -0.08x + 4.83$; $r = -0.16$, $p>0.5$ ($N = 49$).

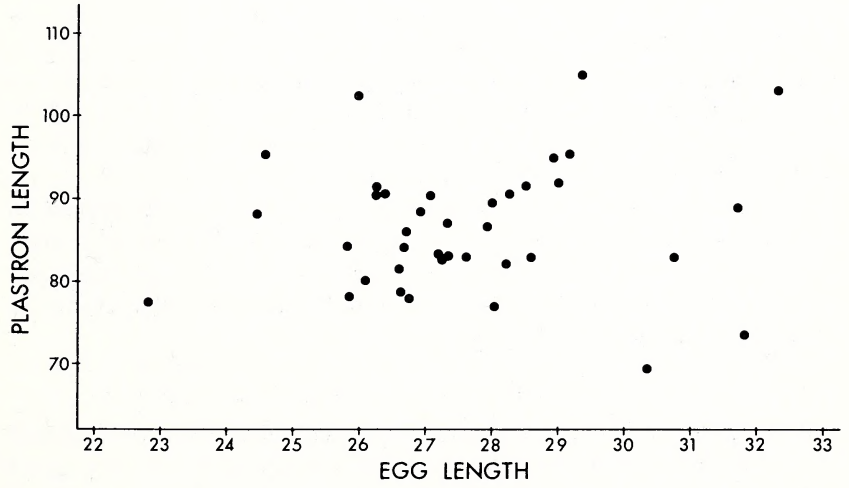

Fig. 2. Relationship between body size (PL in mm) and egg size (mean length for clutch in mm) in *Kinosternon baurii*. Each symbol represents at least one record. Least squares regression is $y = 0.36x + 76.67$; $r = 0.093$, $p>0.05$ ($N = 38$).

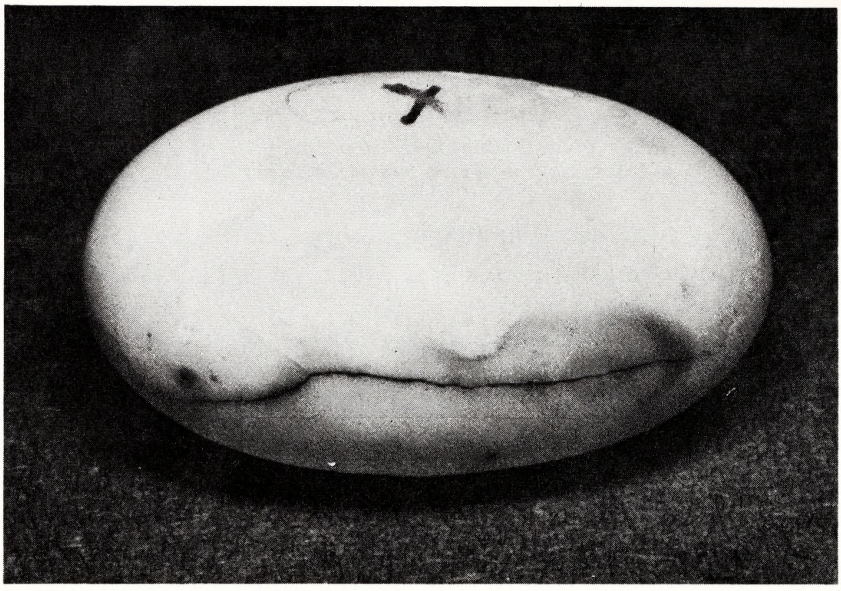

Fig. 3. Typical mid-incubation crack in egg of *Kinosternon baurii* after 103 days incubation. Oviducal egg was removed from female 26 September 1976, crack first appeared 74 days later. Egg hatched after 118 days incubation. × marks top of egg.

Natural nests with eggs in various stages of incubation were found on the following dates: 8 March, 25 April, 7 May, and 20 May 1972; and 19 May (2), and 25 May (2) 1973. Eggs were found buried under 1-3 cm of sand (5 cases) or under moist leaf litter 1 cm or less in depth. Two captive turtles oviposited on 8 February and 17 February 1972, the former in sand and the latter in the water of its tank. Carr (1952) reported finding natural nests from April to June in sand and in piles of dead hyacinths. Captive nestings were observed on 7 March, 9 June, and 19 November by Lardie (1973), and on 4 June by Nicol (1970).

EGGS, INCUBATION, AND HATCHING

The eggs of *Kinosternon baurii* have been described by Einem (1956) and present observations do not differ from his. Mean egg size for 114 eggs I examined was 27.55 (longest diameter; Range = 22.8-32.8) by 16.63 (shortest diameter; Range = 13.6-19.3). Shells of 2 eggs (28.6×16.7; 28.6×16.8) were 0.23-0.28 mm thick at their ends (10 measurements) and 0.34-0.40 thick along the perimeter of their minor axes (10 measurements). Eight eggs (X length 26.6) averaged 4.45 gm each (3.22-5.26).

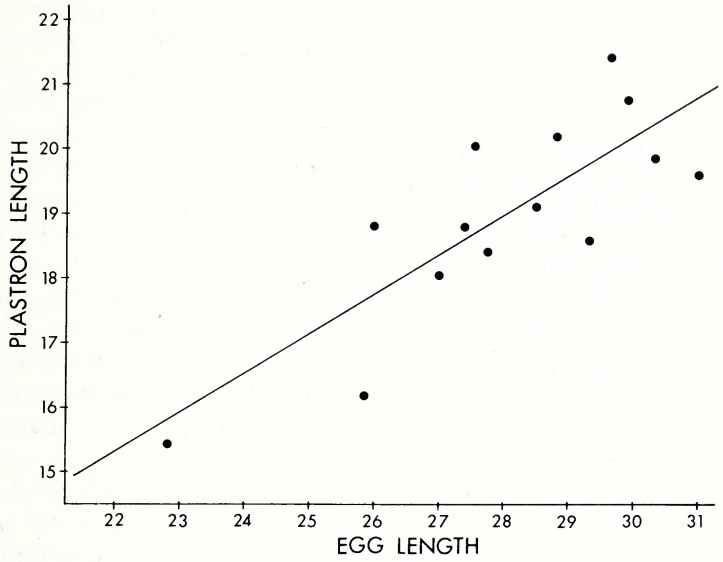

Fig. 4. Relationship between hatchling size (PL in mm) and egg length (mm) in *Kinosternon baurii*. Least squares regression is $y = 0.611 \times + 1.846$; $r = 0.813$, $p<0.01$ ($N = 14$).

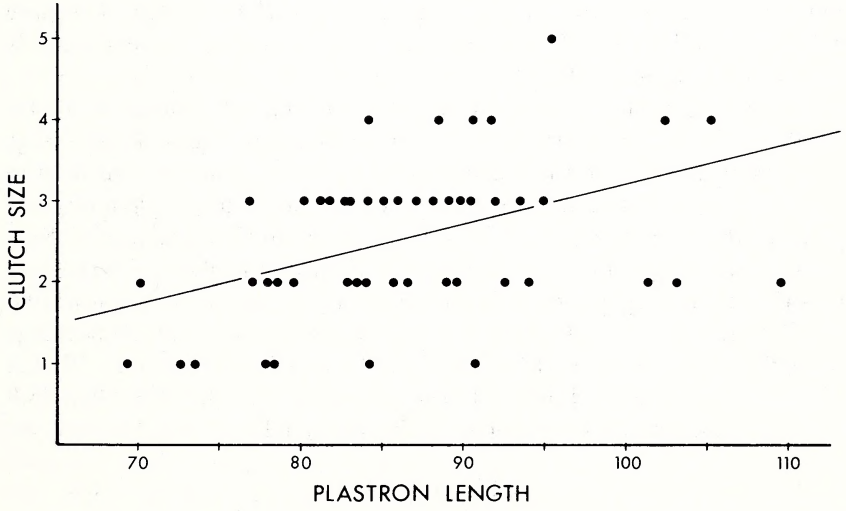

Fig. 5. Relationship between clutch size (based on counts of corpora lutea) and body size in *Kinosternon baurii*. Each symbol represents at least one record. Least squares regression is $y = 0.048 \times -1.630$; $r = 0.442$, $p<0.01$ ($N = 60$).

Seventeen oviducal eggs from central Florida *K. baurii* measured by Einem (1956) averaged 28.0 (Range = 25.0-31.8) by 16.6 mm (15.8-17.2). Lardie (1975) recorded a single central Florida egg of 28×16, and Nicol (1970) measured six south Florida eggs which averaged 23.75 (21-27) by 14.0 (12.5-16). Egg length was not significantly correlated with clutch size (Figure 1) or female PL (Figure 2). No seasonal trends in egg size were identifiable.

Fourteen clutches of oviducal eggs were incubated. Three clutches were opened and preserved after 88, 109, and 114 days, respectively. The remainder were incubated to hatching. At least some of the eggs of all clutches exhibited mid-incubation cracking of the egg shell (Figure 3) as described for *Kinosternon baurii* by Einem (1956) and for *Sternotherus minor* by Iverson (1978a). Not all eggs in any one clutch developed these cracks. Crack formation occurred after an average incubation period of 78.8±16.7 days (Range = 58-113; N = 9 eggs).

Mean incubation time to hatching for 11 clutches was 118.8±11.3 days (Range = 97-143). Eggs from any single clutch hatched within 24 hours of each other, except for one clutch in which 9 days separated the hatching of the 2 eggs. Five eggs incubated by Einem (1956) hatched after 96 to 129 days. Nicol (1970) hatched 4 eggs from the same clutch after 91, 93, 102, and 107 days, respectively. Three eggs from a clutch laid 9 June 1969 were hatched by Lardie (1975) after 117-119 days. Clutches hatched in my laboratory in January (1), February (1), March (3), April (1), June (1), August (2), and September (1). The hatching process was as described by Einem (1956).

Twenty-eight captive hatchlings averaged 19.2 PL (Range = 15.45-22.0) and 22.5 CL (Range = 17.55-25.0). Plastron length of hatchlings was significantly positively correlated (r = 0.813) with egg size (Figure 4). Hatchling-sized turtles were collected in the field on 5 January, 27 January (8), 28 January (5), 4 March (4), 9 March (2), 7 August, 15 September, and 7 December. Most of these had incompletely or very recently closed umbilical openings. Average size of 13 of these neonates was 19.6 PL (Range = 16.55-22.0) and 22.4 CL (Range = 20.4-25.0). Hatchlings from three eggs incubated by Lardie (1975) each measured 19 PL (22 CL); five hatched by Einem (1954) measured 18.1-20.3 PL (20.5-25.0 CL); and four hatched by Nicol (1970) averaged 17.5 CL (15.0-18.5).

CLUTCH SIZE

Clutch size in *Kinosternon baurii* ranged from one to five, two or three being the usual complement. Mean clutch size was insignificantly different whether estimated by counts of enlarged follicles over 10 mm diameter (2.69±0.85; N = 48), oviducal eggs (2.60±0.96; N = 50), or corpora

lutea (2.50±0.87; N = 82). Twelve clutches examined by Einem (1956) and Lardie (1975) averaged 2.33 (Range = 1-3). Nicol's (1970) record of a 6-egg clutch probably represents the maximum for the species. As Einem's (1956) data suggest, clutch size is positively correlated ($p < 0.01$) with plastron length and increases an average of one egg for each 20.8 mm increase in PL (Figure 5). No seasonal trends in clutch size were identifiable.

ANNUAL REPRODUCTIVE POTENTIAL

The ovaries of four females bore two distinct sets of corpora lutea. Clutch sizes of these turtles were 3 (larger set of corpora lutea) and 2 (6 October; 95.4 PL), 2 and 2 (5 January; 101.3 PL), 1 and 1 (20 April; 77.8 PL), and 5 and 4 (20 June; 95.4 PL). All but the last of these also had a set of pre-ovulatory follicles > 10 mm diameter. The ovaries of the first female suggest that following the first clutch of the reproductive season (late August to early September ?), she might possibly nest again in October. If her indicated inter-nest period of about 2 months were maintained, 6 clutches could be produced annually. This relatively long inter-nest interval presumably allows for nearly complete luteal regression between ovulations and may explain why only 4 of 84 females had more than one set of identifiable corpora lutea.

Mature females certainly produce at least three clutches each year. Einem (1956) also suspected that three clutches might be produced annually, and Lardie (1975) reported a captive central Florida female (115 mm CL) which produced three clutches of three eggs each on 7 March, 9 June, and 16 November 1969. If each clutch averages 2.5, average annual reproductive potential is at least 7.5. Field studies will be necessary to determine the actual number of annual clutches.

Reproductive effort per clutch was estimated by the ratio of mean clutch weight (mean egg weight × mean clutch size) to mean total female weight. Clutches in *Kinosternon baurii* average 8.23 per cent (4.45×2.50×100/135.1) of female weight. Unfortunately, similar estimates are available for no other kinosternid turtle.

ACKNOWLEDGMENTS. — I thank Dr.Walter Auffenberg for making the Florida State Museum facilities available to me. Thanks are also due Diderot Gicca, Howard Kochman, Peter Meylan, and Brick Rainey for able field assistance. Numerous other people diligently retrieved specimens killed while crossing roads. Dale R. Jackson offered valuable comments on an early draft of the manuscript. My wife, Sheila, typed the manuscript.

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Accepted 25 June 1978

Fishes of the Gauley River, West Virginia

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ABSTRACT.—The confluence of Gauley River and New River forms the Kanawha River a short distance above Kanawha Falls, West Virginia. A survey of fishes of Gauley River in 1976 yielded 50 species, 25 of which were not previously reported in the literature. Six species (*Lampetra aepyptera, Moxostoma erythrurum, Ictalurus natalis, Ictalurus nebulosus, Noturus flavus, and Percina caprodes*) established new distribution records above Kanawha Falls, which is generally recognized as a major barrier to fish dispersal. Additional verified records increased the total known ichthyofauna to 58 species. These data suggest that fishes which successfully negotiated Kanawha Falls may have found the Gauley River a less strenuous route than the New River for upstream dispersal. Gauley River fauna also may have been influenced by stream captures with Greenbrier and Elk rivers.

INTRODUCTION

Gauley River rises in Webster and Pocahontas counties, West Virginia, and flows west-southwest to Gauley Bridge where it joins New River to form Kanawha River (Fig. 1). The main-channel Gauley is 168 km long, occupies a drainage basin of 3497 km^2 and has an average gradient of 6.1 m/km (Reed 1974). Its headwaters are characterized by broad, meandering, low gradient streams draining the Plateau; the lower section is well known for long rapids, cataracts, large boulders and a deep, narrow V-shaped valley bordered by sandstone cliffs (Reger 1920).

Gauley River apparently retains the old channel it developed on a peneplain during the Cretaceous (Reger 1921), as evidenced by numerous ancient meanders representative of an old base-level bed (Hennen 1919). The length of the river, 168 km, as compared to the airline distance, 95 km (Reed 1974), is indicative of the amount of meandering.

Subsequent uplift of the area during the late Tertiary (Reger 1920) revived the parent stream and caused rapid cutting which resulted in formation of a great gorge, often incised 150 m or more into the Plateau. The presence of a V-shaped lower valley, rather than U-shaped, indicates that the river has not progressed far into its erosional cycle. Many tributaries approach base-level maturation in their heads as well, but have significantly increased gradients in their lower sections indicative of Plateau uplift and stream rejuvenation (Reger 1920). For instance, Meadow River, a major southern tributary, drops over 207 m in the last 18.5 km with an average gradient of 11.4 m/km (Reger 1921).

The only previous systematic survey of the fishes of the Gauley River was that of Addair (1944), who reported on 24 species. C.L. Hubbs, E.C. Raney, and F.J. Schwartz made occasional collections in the drainage, but did not publish their data. Reed's (1974) discussion of the fishery of a portion of the drainage was limited primarily to game species. Jenkins et al. (1972) reported some Gauley River records, but did not discuss the fauna in detail. Ross and Perkins (1959) and Ross (1959) discussed fishes of the New (upper Kanawha) River, but data presented by Jenkins et al. (1972) are more recent.

Zoogeographically, the Gauley River ichthyofauna is identified with the New River drainage (Jenkins et al. 1972), i.e., that portion of the Kanawha River drainage above the 7.3 m high Kanawha Falls (Denoncourt et al. 1975), which has been considered as a major barrier affecting upstream dispersal of fishes (Jenkins et al. 1972; Lachner and Jenkins 1971). Endemism is reportedly high in the upper Kanawha (New/Gauley) River drainage (Hocutt et al. 1978), with the following fishes occurring nowhere else: *Nocomis platyrhynchus, Notropis scabriceps, Phenacobius teretulus, Etheostoma kanawhae* and *E. osburni*. *Cottus carolinae* ssp. (Robins 1954), long thought to be a New River endemic, is also known from one spring in Jefferson County, Tennessee (Etnier, pers. comm). *Exoglossum laurae* and *Percina oxyrhyncha*, species associated with the unique New River fauna, have wider distributions than once thought (Jenkins et al. 1972; Hocutt et al. 1978; Hocutt, in press). The form previously recognized as *Percina maculata* in the upper Kanawha drainage is another endemic species (E. Beckham, pers. comm.).

Various localities within the Gauley River system have been proposed by the Corps of Engineers, Huntington, W. Va., District, as potential sites for location of hydroelectric facilities. Among these sites is a location on the main-channel Gauley River at Swiss that would inundate much of the lower gorge. Collison Creek and Muddlety Creek are among the alternate sites. The U.S. Fish and Wildlife Service, aware of our efforts to survey the streams of West Virginia (Hambrick et al. 1973; Denoncourt et al.

1975; Stauffer et al. 1975; Denoncourt et al. 1977; Stauffer et al. 1977; Hocutt et al. 1978; Stauffer et al. 1977; and Hocutt et al. 1977), contracted this investigation to serve as a basis for their position regarding the proposed Corps' projects on Gauley River.

METHODS AND MATERIALS

Gauley River is rather isolated and offers several distinctive problems in sampling for fishes. Preliminary planning indicated a need to use a variety of collecting gear. Streams were sampled primarily with 1.5 × 3.0 m nylon seines with 3.2 mm mesh or with a pulsated DC electrofishing unit. In more open waters and pools a 1.5 × 7.6 m nylon seine with 3.2 mm mesh was often employed. The electrofishing unit was used exclusively in lower stream sections characterized by large rubble, boulders and high gradient. Four localities in the drainage were sampled with emulsified rotenone using techniques recommended by Hocutt et al. (1973). Trotlines and gill nets were fished overnight in some of the larger pools of Gauley River; these techniques were ineffective due to water clarity and depauperate fauna, so the data were combined with seine data for the particular localities.

A total of 52 stations was sampled in the system (Table 1, Fig. 1), with the expressed purpose of obtaining a representative qualitative sample (Hocutt et al. 1974) at each station. Stations were sampled a single time, except for Station 30 which was sampled by seine and by electrofishing; for the purposes of this report, data obtained in these two collections were combined. Table 2 lists each fish species collected by station. Data are organized for discussion by main-channel and its tributaries. Subsequently, an annotated list of species collected in this survey and by Addair (1944) and Reed (1974) is presented.

All specimens were preserved in a 10 percent formalin solution, unless collected by rotenone. Rotenone collections were preserved in 20 percent formalin (Hocutt et al. 1973). All collections were catalogued into the Fish Museum, Appalachian Environmental Laboratory (AEL 142-194, 226), and stored in 40 percent isopropanol.

Museum records of Gauley River specimens were verified where possible. Museums housing collections from the system include: Cornell University (CU); Ohio State University (OSU); University of North Carolina (UNC); U. S. National Museum (USNM); University of Michigan, Museum of Zoology (UMMZ), where Addair's (1944) collections are catalogued; and Virginia Polytechnic Institute and State University (VPISU).

Jenkins et al. (1972) defined drainages, systems, and basins, and their classification is followed here. Their suggestion that use of these terms be standardized has merit, but certain ambiguities remain. Critical comment is reserved for discussion elsewhere.

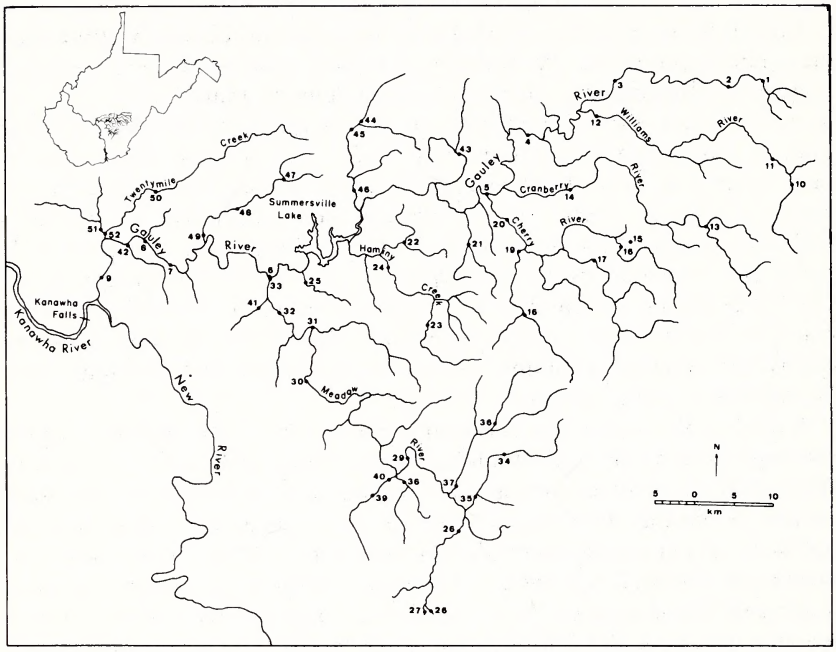

Fig. 1. Map of Gauley River drainage, West Virginia, with fish sampling localities noted.

Table 1. Fish sampling localities on the Gauley River, West Virginia. Appalachian Environmental Laboratory (AEL) catalogue number, date of collection and time of collection are in parentheses.

Station No.	Locality Description
1	Headwaters of Gauley River, mouth of Big Run, Webster Co. (AEL 165; 6/9/76; 1100).
2	Gauley River, old tipple at Jerrysville, Webster Co., WV (AEL 167; 6/9/76; 1245).
3	Gauley River, 3.2 km s on Route 20 from junction Co. Rd. 42, Bolair, Webster Co. (AEL 180; 6/9/76; 1445).
4	Gauley River at Gauley Mills, Webster Co. (AEL 179; 6/9/76; 1630).
5	Confluence of Gauley and Cherry rivers, Route 20 bridge, Nicholas Co. (AEL 181; 6/11/76; 1130).
6	Gauley River, at mouth of Meadow River, Carnifex Ferry, Fayette Co. (AEL 187; 7/6/76; 0900).
7	Gauley River, secondary road paralleling Peter's Creek, then downstream along Gauley for ca. 8.0 km, Nicholas Co. (AEL 188; 8/2/76; 1000).
8	Gauley River, mouth of Laurel Creek, Swiss, Nicholas Co. (AEL 185; 8/26/76; 1300).
9	Gauley River, first riffles above mouth, midway between Vanetta and Gamoca, Nicholas Co. (AEL 147; 8/9/76; 1430).
10	Williams River, Williams River Road, Williams River Campground, 4.8 km from Handley, Pocahontas Co. (AEL 186; 6/11/76; 0900).
11	Williams River, Scenic Route 150 bridge, Pocahontas Co. (AEL 182; 6/10/76; 0930).
12	Williams River bridge at Dyer, Webster Co. (AEL 165; 6/8/76; 1900).
13	Confluence North and South Forks of Cranberry River, Pocahontas Co. (AEL 163; 6/10/76; 1230).
14	Cranberry River at Little Bee Run, 0.96 km upstream of bridge at Big Rock Campgrounds, Nicholas Co. (AEL 166; 6/8/76; 1750).
15	Summit Lake, just off Route 39, Pocahontas Co. (AEL 161; 6/10/76; 2030).
16	North Fork of Cherry River, north bend of picnic area near road to Summit Lake, Greenbrier Co. (AEL 169; 6/8/76; 1030).
17	South Fork Cherry River, 5.3 km upstream of bridge across North Fork of Cherry, e of Richmond, Greenbrier Co. (AEL 183; 6/8/76; 1200).
18	Laurel Creek, at confluence McMillion Creek, Namo Chapel, Greenbrier Co. (AEL 175; 6/8/76; 1430).

Table 1. (Cont.)

Station No.	Locality Description
19	Laurel Creek, 0.48 km s of Route 39, Fenwick, Nicholas Co. (AEL 193; 6/8/76; 1345).
20	Cherry River, Route 20 bridge, Holcomb, Nicholas Co. (AEL 178; 6/10/76; 1530).
21	Panther Creek, Route 39/20 bridge, east of Nettie, Nicholas County (AEL 176; 6/11/76; 1400).
22	Deer Creek at Deepwell, Nicholas Co. (AEL 191; 6/11/76; 1220).
23	Hominy Creek at Hominy Falls, Nicholas Co. (AEL 184; 6/11/76; 1530).
24	Hominy Creek, ford 6.4 air km e of Mt. Nebo, Nicholas Co. (AEL 142; 7/7/76; 1515).
25	Collison Creek, Nicholas Co. (AEL 157; 7/7/76, 1100).
26	Meadow River, co. rd. bridge just w of Grassy Meadows, Greenbrier Co. (AEL 150; 7/8/76; 1400).
27	Meadow River, 0.27 km w of Station 26, w of Grassy Meadows, Greenbrier Co. (AEL 149; 7/8/76; 1330).
28	Meadow River, co. rd. bridge nw of Meadow Bluff, Greenbrier Co. (AEL 151; 7/8/76; 1400).
29	Meadow River, Route 60 bridge, n of McRoss, Greenbrier Co. (AEL 153; 7/8/76; 1630).
30	Meadow River, Russelville, WV (Babcock Railroad Junction), Fayette Co. (AEL 159; 7/10/76; 1545) (AEL 192; 8/25/76; 1300).
31	Meadow River at mouth on Anglins Creek, Nicholas Co. (AEL 155; 7/7/76; 1300).
32	Meadow River, below new Route 19 bridge, Fayette Co. (AEL 173; 7/6/76; 1000).
33	Mouth of Meadow River, Fayette Co. (AEL 152; 7/5/76; 1500).
34	Little Clear Creek, Raders Run Railway Crossing, on Co. Rd. 1, Greenbrier Co. (AEL 174; 6/11/76; 1800).
35	Little Clear Creek, Route 60 bridge, Shawyer's Crossing, Greenbrier Co. (AEL 156; 7/10/76; 1300).
36	Big Clear Creek at Anjean, Greenbrier Co. (AEL 177; 6/11/76; 1650).
37	Big Clear Creek, Route 60 bridge, Rupert, Greenbrier Co. (AEL 172; 7/10/76; 1215).
38	Little Sewell Creek, co. rd. bridge, just downstream of confluence Boggs Creek, Greenbrier Co. (AEL 170; 7/8/76; 1500).
39	Sewell Creek at Lilly Park, Greenbrier Co. (AEL 158; 7/8/76; 1030).

Table 1. (Cont.)

Station No.	Locality Description
40	Sewell Creek, Route 60 bridge, Rainelle, Greenbrier Co. (AEL 144; 7/8/76; 1115).
41	Dogwood Creek, Saturday Rd. Bridge, Fayette Co. (AEL 162; 7/10/76; 1010).
42	Mouth of Rich Creek at Jodie, Fayette Co. (AEL 160; 7/11/76; 1040).
43	Big Beaver Creek, Route 41 bridge, Craigsville, Nicholas Co. (AEL 189; 8/24/76; 1420).
44	Brushy Fork, Route 43 bridge, Muddlety, Nicholas Co. (AEL 168; 7/11/76; 1700).
45	Muddlety Creek below confluence Brushy Fork and McMillion Creek, s of Muddlety, Nicholas Co. (AEL 194; 7/11/76; 1745).
46	Lower Muddlety Creek at end of private drive off Route 39, Rev. Mycott property, Nicholas Co. (AEL 190; 8/25/76; 1100).
47	Confluence of Peter's Creek and Buck Garden Creek, Gilboa, Nicholas Co. (AEL 143; 7/11/76; 1500).
48	Peter's Creek, Summersville Dam rd. bridge, Drennen, W. Va. (AEL 171; 7/11/76; 1415).
49	Peter's Creek, along co. rd., 3.7 km s of Lockwood, above major water falls, Nicholas Co. (AEL 145; 7/11/76; 1310).
50	Twentymile Creek, at confluence Ash Fork, Nicholas Co. (AEL: 7/9/76; 1830).
51	Bell's Creek, first bridge (residential) above confluence Twentymile Creek, Fayette Co. (AEL 148; 7/9/76; 1700).
52	Confluence of Twentymile Creek and Bells Creek, Nicholas-Fayette Co. line (AEL 154; 7/9/76; 1930).

RESULTS

Sub-drainages

Main-channel

That portion of the Gauley River above the mouth of Cherry River is approximately 67 km in length and has an average gradient of 4.5 m/km; the major tributaries are Williams, Cranberry and Cherry rivers, in descending order (Fig. 1). From the confluence of Cherry River to the Route 39 bridge (near the head of Summersville Reservoir), Gauley River

drops 104 m in 24 km (gradient, 4.2 m/km), and begins the descent into its gorge. Summersville Dam is constructed across the gorge at or near the mouths of Battle Run and McKee Creek, and has a normal pool elevation of 503 m to above the Route 39 bridge approximately 22.5 km upstream. In the vicinity of the dam the gorge is cut nearly 152 m below the level of the Plateau. Hominy and Big Beaver creeks are the major tributaries between Summersville Dam and Cherry River.

Progressing downstream 9.7 km from the Summersville Dam to Carnifex Ferry at the mouth of Meadow River, Gauley River descends an additional 65 m at an average gradient of 6.7 m/km. Meadow River, the only significant tributary, has a large drainage basin, near 932 km^2, as compared to 1932 km^2 in the Gauley River basin above the confluence. Collison Creek also enters this section of the river with an average gradient of 28.4 m/km over its 10 km length. From Carnifex Ferry to Swiss the Gauley River continues its run through the gorge and is characterized by torrential water, boulder and bedrock substrate, and an average gradient over 3.8 m/km for the 30.5 km distance. The river then approaches base-level with an average gradient of 1.1 to 1.3 m/km, and with long riffle and pool habitats alternating over the last 14.5 km to its confluence with New River. These physical characteristics and associated stresses influence distribution of fishes throughout the drainage. In this survey, 31 species were collected in the main-channel Gauley River, Stations 1 through 9 (Table 2).

Williams River

Williams River heads against Dry Mountain, Pocahontas County, at an elevation of 1210 m and discharges into Gauley River near Cowen at an elevation of 689 m. Length of the stream is 54 km and average gradient is 11.5 m/km. The drainage basin of Williams River, 337 km^2, is larger than Gauley River above their confluence. A total of 23 species was collected in the Williams River subdrainage, Stations 10 through 12 (Tables 1 and 2; Fig. 1).

Cranberry River

Cranberry River rises in Pocahontas County at approximately 1402 m in elevation, flows north, then southwest to enter Gauley River at Cranberry Station at 585 m. Length of the river is 51.5 km and gradient is 15.9 m/km. The basin is 181 km^2 in size. Associated with the river is the Cranberry Back Country and Wilderness Study Area, a 14690 hectare tract that is regulated by the U.S. Forest Service and has been promoted for inclusion as a Wilderness Area. Nine species were collected from two stations (13, 14) on Cranberry River (Tables 1 and 2; Fig. 1). Generally,

Cranberry River has a depauperate fauna which probably resulted from a past history of intensive logging and mining, as well as naturally low pH waters draining Cranberry Glades.

Cherry River

Cherry River, a major southern tributary to Gauley River, rises at 1341 m in Greenbrier County and flows generally in a northeast direction for 43.4 km to its mouth at Curtin. The drainage basin is 445 km^2 in size and gradient averages 17.4 m/km. Cherry River is rather industrialized in its lower section and domestic sewage also adds to the degradation of water quality. Major tributaries to Cherry River are the North Fork, South Fork and Laurel Creek. A small impoundment, Summit Lake, is located off Route 39, and discharges into the North Fork. Six stations (15-20) were located in the Cherry River drainage (Tables 1 and 2; Fig. 1). Summit Lake (Station 15) is a well used recreation area stocked with *Lepomis macrochirus, Micropterus salmoides* and salmonids.

Panther Creek

Panther Creek is a small southern tributary to Gauley River east of Nettie. It is approximately 15.4 km long with an average gradient of 23.3 m/km. One collection was made on Panther Creek at Station 21 yielding only 4 species (Tables 1 and 2; Fig. 1).

Hominy Creek

Hominy Creek is a principal southern tributary to Gauley River, with its source near 1097 m in elevation at Grassy Knob, Greenbrier County. Its length is approximately 35.1 km with an average gradient of 18 m/km. The drainage basin is about 272 km^2. A vertical drop of 6.1 m occurs at Hominy Falls. A total of 15 species was collected from the system (Stations 22-24) (Tables 1 and 2; Fig. 1).

Collison Creek

This stream is a small tributary to Gauley River below Summersville Dam. It is being considered as a possible site for impoundment by the Corps. Total length is 9.5 km and gradient is 28.8 m/km. The drainage basin is 24.9 km^2. One collection (Station 25) on Collison Creek yielded 7 species (Tables 1 and 2; Fig. 1).

Meadow River

Meadow River, the major tributary to Gauley Rvier, rises in eastern Summers County at approximately 1202 m and flows north to northwest along the Fayette-Greenbrier and Fayette-Nicholas county lines to its

mouth at Carnifex Ferry. Its total length is 80.5 km and the drainage basin is 932 km². Gradient averages 10.4 m/km and increases from head to mouth. Meadow River headwaters are along the broad Appalachian Plateau, but in the last 17.7 km it enters its own scenic gorge to Carnifex Ferry. Sixteen stations were located in the Meadow River system: main-channel (Stations 26-33), Little Clear Creek (34-35), Big Clear Creek (36-37), Sewell Creek (38-40), and Dogwood Creek (41). A total of 28 species was collected in the system (Tables 1 and 2; Fig. 1).

Rich Creek

This is a small tributary to Gauley River at Jodie, W. Va. Total length is near 12.2 km and average gradient is 45 m/km. The stream was surveyed at its mouth (Station 42), particularly in a pool area adjacent to but not a part of Gauley River. A total of 15 species was collected (Tables 1 and 2; Fig. 1).

Big Beaver Creek

This stream rises at 792 m in Webster County and is approximately 27.4 km in length. The gradient is 10.2 m/km and the drainage basin is 101 km². Seven species were collected at Station 43 (Tables 1 and 2; Fig. 1).

Muddlety Creek

Muddlety Creek, about 32 km in length, rises at an elevation of 731 m and enters Gauley River at Route 39 bridge. The drainage basin is 172 km² and gradient is 8.0 m/km. The stream had been rechanneled along much of the section below Muddlety, and road construction was present adjacent to the stream. Coal washings were abundant in the substrate. Thirteen species were collected from Stations 44-46 (Tables 1 and 2; Fig. 1). In general, the fauna was depauperate for the above reasons. This stream is presently being considered for impoundment by the Corps.

Peters Creek

Peters Creek originates north of Summersville and flows southwest for 28.1 km to its confluence with Gauley River. Gradient averages 10.8 m/km and the basin is approximately 135 km². A substantial waterfall of about 10-12 m exists 1.6 km above its mouth. Eleven species were collected from this subdrainage at Stations 47-49 (Tables 1 and 2; Fig. 1).

Twentymile Creek

Twentymile Creek is the largest northern tributary to Gauley River. It occupies a drainage basin of about 272 km², and has a total length of 43.1

km. Gradient averages 10.2 m/km. Its principal tributary is Bells Creek. Twentymile Creek was relatively productive with 21 species collected at three localities (Stations 50-52) (Tables 1 and 2; Fig. 1). This was probably due to a combination of factors, including its close relationship to Gauley River below the gorge.

Annotated List of Species

The discussion of species collected in this survey is supplemented by other collections cited in the literature and verified museum records. Species are presented in phylogenetic order (Bailey et al. 1970). Considering the minimal information available on the Gauley River ichthyofauna, this discussion should prove beneficial for future comparisons.

Petromyzontidae

Lampetra aepyptera.— One specimen of the least brook lamprey (AEL 181), a non-parasitic species, was collected in Gauley River at the mouth of Cherry River. The specimen was an ammocoete taken over a detritus bank from an eddy at the lower tip of a mid-channel island. Continued seining and bank kicking did not produce additional specimens.

This record is the first report of *L. aepyptera* above Kanawha Falls. Its presence in other West Virginia drainages was documented by Addair (1944), Jenkins et al. (1972) and Stauffer, Denoncourt and Hocutt (ms.). The specimen was taken above Summersville Reservoir, which infers an established population prior to dam construction. Hocutt (1975) and Stauffer (1975) did not report it from the upper New River system, Virginia though they made extensive collections throughout the drainage.

Anguillidae

Anguilla rostrata.—Addair's (1944) collections of the American eel from Greenbrier River (one collection) and New River (two collections) were the only documented reports of this species in the upper Kanawha River drainage. A single specimen of *A. rostrata* (ca. 1 m TL), reported in this survey from Gauley River at the mouth of Meadow River below Summersville Dam (AEL 187), was found dead on the bank with an angler's hook and line attached.

Salmonidae

Salmo gairdneri.—Rainbow trout are routinely stocked by the W. Va. Department of Natural Resources.

Salmo trutta.—Brown trout are also commonly stocked in West Virginia.

Salvelinus fontinalis.—The Brook trout is indigenous to much of the Appalachian Plateau and natural populations are to be found in pristine habitats common to Gauley River headwaters.

Cyprinidae

Campostoma anomalum.—The Stoneroller is common throughout the upper Kanawha River drainage. Addair (1944) collected it from eight of 19 sampling localities on Gauley River. This survey reports it from 27 of 52 stations. Verified museum records are CU 32399; UMMZ 95280, 95293, 108166, 108176, 165698, 165705, 165754.

Clinostomus funduloides. —Addair (1944) reported the Rosyside dace from two Kanawha River localities, one of which was on Meadow River near Russelville (Station 30, Fig. 1). Hocutt et al. (1978) reported it from three localities in the Greenbrier drainage. It was found in this survey at five stations: Cherry River (Stations 17 and 20) and Meadow River (Stations 38, 39, 40). Its distribution appears limited to higher elevations and colder waters. Another record is from Cherry River (UNC 3315).

Ericymba buccata.—Addair (1944) collected the Silverjaw minnow in six of 87 collections above Kanawha Falls, including three localities in the Gauley drainage: Twentymile Creek, Peters Creek and Williams River. It was common at ten of the 20 localities where we collected it. Factors affecting its distribution (Wallace 1972; 1973) appear to be favorable under present conditions. Previous museum records are UMMZ 95294; USNM (RVM-260).

Exoglossum laurae.—The Tonguetied minnow was collected by Addair (1944) at three Williams River localities. It was not abundant in this survey, with only eight specimens collected from headwater stations of Williams River (Station 11, AEL 182), Cranberry River (13, AEL 163) and Cherry River (17, AEL 183; 18, AEL 175).

Nocomis platyrhynchus.—The Bigmouth chub is endemic to the upper Kanawha River drainage above Kanawha Falls (Lachner and Jenkins 1971). The sibling species, *N. micropogon*, occurs commonly in all other drainages of the greater Ohio River, including the lower Kanawha River, and Atlantic slope heading in West Virginia. Many diagnostic characteristics of the two species are similar, with overlap occurring between morphometric and meristic ranges; it is distinguished from *N. platyrhynchus* chiefly by tuberculation patterns. Despite six new distributional records for fishes above Kanawha Falls, it was necessary to consider all *micropogon*-group chubs collected in Gauley River as *N. platyrhynchus* for the reasons cited.

Addair (1944) collected *N. platyrhynchus* from five localities. This survey found it at 23 stations where it was often abundant. The use of elec-

trofishing gear and rotenone provided advantages of capture which Addair did not enjoy. Chubs were no doubt present throughout the drainage at the time of his survey, but they are difficult to collect by seine due to their habitat preference for rapid runs with large rubble and boulder substrate. Other records are UNC 6083, CU 28867; UMMZ 95281, 108168, 165699, 165706, 165755.

Notemigonus crysoleucas.—Collection of the Golden shiner from Gauley River at Carnifex Ferry (Station 6) represents the first record of this species from the Gauley drainage. It is widely used by fishermen, and its occurrence is attributed to bait bucket introduction.

Notropis albeolus.—Previous efforts by Addair (1944) and others did not yield representatives of the *Notropis* subgenus *Luxilus* from Gauley River. Hocutt et al. (1978) noted that Gilbert (1964) and R.D. Ross (VPISU 2429) took *N. albeolus* from Greenbrier River, and Hocutt (1974) and Stauffer (1975) found it in New River, Virginia. We collected the White shiner from nine localities where its presence was rare to abundant. The reason for its absence in previous collections is speculative.

Notropis chrysocephalus.—The Striped shiner is also a member of the subgenus *Luxilus* (Gilbert 1964). Gilbert (1964) considered *N. chrysocephalus* to be introduced to the upper Kanawha drainage, but common in other Ohio River drainages. We collected it at five localities, but it was abundant only at the mouth of Cherry River (Station 5). It was apparently collected by Schwartz from Gauley River east of Bolair (UNC 685) and Williams River (UNC 6087), but these records are not confirmed.

Notropis photogenis.—Addair (1944) reported the Silver shiner from one Peter's Creek locality and two Meadow River stations. We found it at ten stations, distributed from the headwaters to our most downstream station on Gauley River. The only other record of the Silver shiner from the Gauley system is UMMZ 95283.

Notropis rubellus.—The Rosyface shiner was one of the most abundant and widely distributed minnows collected in this survey, taken from 25 stations. Addair (1944) collected it from ten of 19 stations on Gauley River. Other records are UNC 6086, UMMZ 95285, 108170, 165700, 165707, 165756.

Notropis scabriceps.—The New River shiner is endemic to the upper Kanawha River drainage. We collected a single specimen from Williams River (Station 12; AEL 164). Although never abundant, Addair (1944) found it more widely distributed, collecting it from seven localities: Peters Creek (1 station), Muddlety Creek (1), Cherry River (2) and Williams River (3). This species deserves recognition by the W.Va. Department of Natural Resources as a threatened or endangered species. Its ecological requirements are not known, but its distribution appears to coincide with

high elevation, cold water streams. We found it at one of 52 localities in the Gauley River (Station 12, AEL 182) and Hocutt et al. (1978) found it at 5 of 32 localities on Greenbrier River. It was also previously collected from Peters Creek (UMMZ 95295), Muddlety Creek (UMMZ 108172), Panther Creek (UMMZ 1081178) and Williams River [USNM-(RVM-260)] in the Gauley system.

Notropis spilopterus.—The Spotfin shiner was the only species collected by Addair (1944) not found in this investigation. He collected it from Big Creek (a lower tributary to Gauley River) and two localities on Meadow River, and concluded it avoids high upland streams. It is also known from Gauley River, Route 41 bridge (CU 32391, 32391) and at the confluence of Gauley River and Twentymile Creek (UMMZ 95284).

Notropis stramineus.—Addair (1944) found the Sand shiner at Big Creek and two Meadow River localities. We collected it at six localities (Stations 9, 48-52) in the lower Gauley River system.

Notropis telescopus.—Collections of the Telescope shiner from Stations 8 (15 specimens; AEL 185) and 50 (1; AEL 146) represent the first records of this species from Gauley River. Gilbert (1969) considered *N. telescopus* as introduced to New River and Hambrick et al. (1973) first reported it from West Virginia. Hocutt et al. (1978) subsequently found it in Greenbrier River. Additionally, we have recent records from tributaries to Kanawha River below Kanawha Falls.

Notropis volucellus.—Addair (1944) found the Mimic shiner common in New and Kanawha rivers, but collected it at only two Gauley River localities. We collected it from six localities (Stations 4, 5, 6, 8, 9 and 52). Its distribution in the main-channel Gauley indicates an ability to tolerate, if not a preference for, large water. Evidence presented by Hocutt et al. (1978) supports this hypothesis. Other records from the Gauley system are CU 32532; UMMZ 95282, 108171.

Phenacobius teretulus.—The Kanawha minnow is endemic to the system above Kanawha Falls, but is rarely taken in West Virginia. Hocutt et al. (1978) reported three specimens from Greenbrier River. Hambrick et al. (1975) reviewed life history aspects of *P. teretulus*, noting only three collections of the species in West Virginia, all predating 1940. We collected only two specimens from upper Laurel Creek (Cherry River system; Station 18, AEL 175) during this study. Hocutt et al. (1978) recommended its consideration as an endangered species; these data support that conclusion.

Pimephales notatus.—Surprisingly, Addair (1944) collected the Bluntnose minnow from only one locality in the Gauley system, Twenty-mile Creek. We collected it at 32 stations, making it one of the more widely distributed species encountered. There is a distinct preference of this species

for sandy, silt-laden pool or eddy habitats. Other records include: CU 32531; UMMZ 95286; USNM (RVM-260).

Pimephales promelas.—This study yielded 14 specimens of the Fathead minnow from upper Williams River (Station 10, AEL 186). They were collected in a standing back water area clogged with filamentous algae, and represent the first records of the species from the system. Williams River is noted for its trout fishing and the occurrence of this minnow is attributed to bait bucket introduction.

Rhinichthys atratulus.—The Blacknose dace was a widely encountered species in this study, found at 23 stations. Addair (1944) collected it from 11 localities. It is known from other collections: UMMZ 95297, 108173, 108177, 108183, 131827, 165701; USNM 196458.

Rhinichthys cataractae.—The Longnose dace was not reported from Gauley River by Addair (1944). We found it at 18 localities where it was locally abundant. Other records are from: Williams River [OSU (LM-76-7), collected concurrent with this survey; UMMZ 165708]; Cranberry River (UMMZ 165702); Peters Creek (UMMZ 95296); and Gauley River (CU 32398).

Semotilus atromaculatus.—The Creek chub is a headwater species which Addair collected at nine localities; we sampled it from 37 stations. Other records are OSU (LM-76-7); UMMZ 95292, 108167, 165703, 165709, 165757; USNM (FJS 710).

Ictaluridae

Ictalurus natalis.—One specimen of Yellow bullhead (AEL 150) from upper Meadow River is the first record of this species from the Gauley, and also represents the first record of the species above Kanawha Falls (Jenkins et al. 1972). It was collected from a small pool in the headwaters, bordered by pasture. The specimen may be representative of an indigenous population, or introduced to the system. Addair (1944) collected two specimens from a tributary to lower Kanawha River.

Ictalurus nebulosus.—The collection of a Brown bullhead (AEL 174) from upper Little Clear Creek is the first confirmed record of the species above Kanawha Falls (Jenkins et al. 1972; Hocutt 1974; Stauffer 1975). It was collected with electroshocking gear in a pool averaging 1.4 m in depth, 9.1 m wide and 30 m long. Other bullheads were observed swimming at the surface, but not collected.

Noturus flavus.—Eight specimens (AEL 185) of the Stonecat collected by rotenone from the Gauley River at Swiss, West Virginia (Tables 1 and 2: Fig. 1), represent the first reported record of this species from the entire Kanawha River drainage above or below Kanawha Falls. Station 8 was characterized by a long riffle/run (90 m) habitat that opened into a pool

and was channelized on the right side of an island at the mouth of Laurel Creek. A collection (CU 32540) of the Stonecat from Gauley River, Route 41 bridge, in 1951 has been confirmed (E. Brothers, pers. comm.), which infers that *N. flavus* is native to the Gauley drainage.

Pylodictus olivaris.—Flathead catfish collected at the mouth of Meadow River (Station 33) by rotenone are the first specimens from the Gauley system reported in the literature. It was known from previous surveys above and below Kanawha Falls (Addair 1944; Jenkins et al. 1972; Hocutt 1974; Stauffer 1975), and is routinely taken by anglers (pers. comm.) from Gauley River. Specimens previously collected from Gauley River are housed at Cornell (CU 32397, 32535).

Centrarchidae

Ambloplites rupestris.—Addair (1944) did not collect the Rockbass from the Gauley system, but Reed (1974) reported it. We collected it from 22 stations and it was rarely abundant. Other records include: CU 32400, 32534; and UMMZ 9529, 165760.

Lepomis cyanellus.—Jenkins et al. (1972) considered the Green sunfish as probably introduced above Kanawha Falls. Our records of it from eight stations are the first reported from the Gauley. It was not abundant, although widely distributed, and was collected almost exclusively from small to moderate size streams with pool habitats.

Leopmis gibbosus.—We collected one adult specimen, a probable introduction, from lower Big Clear Creek (Station 37, AEL 172). The site was characterized by a long base-level pool, and banks which were strongly undercut. Another museum record from Gauley is CU 32539.

Lepomis macrochirus.—Addair (1944) collected the Bluegill from a lower Gauley tributary, Big Creek. We found it at four stations (6, 15, 28 and 43).

Micropterus dolomieui.—Smallmouth bass were collected by Addair (1944) from five stations and by Reed (1974) from various localities. It was widely distributed in this survey, being collected at 22 localities. Other records are CU 32392; and UMMZ 95289, 95291, 165713, 165761.

Micropterus punctulatus.—The species was not collected by Addair (1944) from Gauley River, although he found it at several localities in the Kanawha drainage where it is native (Jenkins et al. 1972). It was collected by Hocutt (1974), Stauffer (1975) and Hocutt et al. (1978) from the New system. We found it at five stations in this survey.

Micropterus salmoides.—We collected the Largemouth bass from three stations. It is regarded as introduced.

Percidae

Etheostoma blennioides.—Greenside darters were collected from upper Meadow River (2 stations), Cranberry River (1) and Williams River (1) by Addair (1944). Other collections are OSU (LM-76-7); CU 25393, 32396, 32536; UMMZ 95279, 165710, 165758. We collected it from 26 stations and it was locally abundant.

Etheostoma caeruleum.—The first record of the Rainbow darter above Kanawha Falls was reported in Hocutt et al. (1973) from New River just above the mouth of East River. Subsequently, it was collected from East River by Hambrick et al. (1973) and Stauffer et al. (1975), and from New River (Stauffer 1975). A total of 272 specimens was taken in this survey from six stations on the lower Gauley (AEL 146, 147, 148, 154, 160, 185). No other records are known from above the Falls. Two dams, several cataracts and the New River gorge separate this population from the small one described by Hocutt et al. (1973) in the vicinity of East River. Masnik, Hocutt, and Stauffer (ms) made over 200 collections in the upper New River system, West Virginia, Virginia and North Carolina, 1971-1975, and no other populations of *E. caeruleum* were located. Thus, the East River population appears to be a relict, virtually isolated from other populations.

Eheostoma flabellare.—Addair (1944) collected the Fantail darter from 14 of 19 localities sampled. We also found it widely distributed. Museum records are: OSU (LM-76-7); UMMZ 95278, 108174, 108181, 108182, 131826, 165704, 165711, 165759.

Etheostoma nigrum.—Addair (1944) was the first to report the Johnny darter above Kanawha Falls, collecting it at two localities: New River above the confluence with Gauley River; and Glade Creek, tributary to New River. He felt that its absence in Gauley River was related to rapid currents and lack of suitable substrate for food organisms. We found it at 13 localities distributed from the headwaters to the mouth. Its distribution and absence above Summersville Dam indicate that it is indigenous to the system. The only record located in addition to Addair (1944) was from Gauley River, Route 41 bridge south of Summersville, West Virginia (CU 32537).

Etheostoma osburni.—The Finescale saddled darter is endemic to the Kanawha River drainage above Kanawha Falls. Jenkins et al. (1972) reported it from Elk River below the Falls; however, the validity of these data is doubted (R.E. Jenkins, pers. comm.). Our recent efforts in Elk River have yielded only *E. variatum*, a sibling species. Addair (1944) found *E. osburni* in upper Gauley River (1 station), Williams River (1) and Cherry River (2). We found it at ten localities (Tables 1 and 2; Fig 1), being more predominant in the headwaters than the lower drainage. Other

collections are OSU (LM 76-7); CU 25394; UMMZ 165712. Collections catalogued from Gauley River as *E. kanawhae* (UNC 7006) and *E. variatum* (UNC 6704) are regarded as *E. osburni*; we are not aware of verified museum records of *E. kanawhae* from West Virginia.

Percina caprodes.—Specimens of the Logperch collected from Stations 8 (AEL 185) and 9 (AEL 147) represent the first reported records of this species above Kanawha Falls. Addair (1944) collected it below the Falls, and concluded that it was one of the darters unable to make it over that physical barrier into the upper Kanawha drainage. Our specimens were collected by rotenone (Station 8) and electrofishing (9) from extensive riffle/run habitats characterized by moderate to large rubble substrate. Our experience indicates that the Logperch is most often collected just below a "lip" or dropoff where the riffle becomes a run. Other specimens of *P. caprodes* are known from upper New River, Grayson County, Virginia (R.E. Jenkins, pers. comm.), but not reported in the literature.

Percina cf. *maculata*.—The endemic relative of the Blackside darter occurs above Kanawha Falls in the Kanawha River drainage (Jenkins et al. 1972; Hocutt 1974; Stauffer 1975; Hocutt et al. 1978) and is currently being described by E. Beckham. Addair (1944) collected it from one station on upper Williams River. We collected it from six localities chiefly in cold upland streams (Tables 1 and 2; Fig. 1). Past experience indicates that it is widely distributed throughout the New River system, but rarely abundant. The only other museum record from Gauley River is CU 28866.

Percina oxyrhyncha.—The Sharpnose darter has long been identified with the ichthyofauna of the upper Kanawha River drainage; however, its distribution is wider than once expected (Jenkins et al. 1972; Hocutt and Hambrick 1973; Denoncourt et al 1977; Hocutt et al. 1978; Thompson 1977; Hocutt, in press). Further, it was once considered by the U.S. Department of Interior for posting as a threatened or endangered species. Recent collecting in the upper New River (Hocutt et al. 1973; Hocutt 1974; Stauffer 1975) has shown that it is locally abundant. Hocutt et al. (1973) collected 33 specimens from New River at Lurick, Virginia. Specimens from eight Gauley River stations are the first reported from the system (Table 1; Fig. 1). At the mouth of Meadow River (Station 33), 54 specimens were collected with rotenone. As suggested by Denoncourt et al. (1977), the preference of adult *P. oxyrhyncha* for habitats with a large rubble and boulder substrate probably accounts for the paucity of known specimens before our work in the 1970's. The only other records of it from the Gauley system are CU 28868 and 32538 from Route 41 bridge south of Summersville.

Stizostedion vitreum.—Reed (1974) first discussed Walleye in the Gauley River system. A rotenone sample from the mouth of Meadow River produced one specimen in this survey.

Cottidae

Cottus bairdi.—Prior to this survey, records of *Cottus* were not known from Gauley River. Three specimens of *C. bairdi* were collected from Williams River, Station 11 (AEL 182). They were distinguished by characters recommended by Robins (1954). One other collection exists (OSU-LM 76-7), made concurrently with this survey from Williams River.

Cottus carolinae ssp.—*C. carolinae* were collected from habitats with moderate to large rubble in Williams River (Stations 10, 11) and Peters Creek (47, 48).

Other Species

Other species are known to occur in the Gauley River system. *Perca flavescens, Lepomis auritus, Pomoxis annularis,* and *Pomoxis nigromaculatus*, occur in Summersville Reservoir (C. Clower, pers. comm.), where they presumably have been introduced. Reed (1974) reported stocking of *Esox masquinongy* in Meadow River. *Ictalurus punctatus* (CU 32393, 32533) was taken from Gauley River, Route 31 bridge, 4.8 km south of Summersville, prior to constuction of Summersville Dam. Subsequent to our survey, the W. Va. Department of Natural Resources collected specimens of *Phoxinus oreas* 36 km upstream of the mouth of Williams River (R.L. Miles, pers. comm.).

Expected Species

Hocutt et al. (1978) treated the fishes of Greenbrier River and included information on species known from the main-channel New River between Claytor Lake, Virginia, and Kanawha Falls, West Virginia. It is possible that some of these species may potentially occur in Gauley River, e.g., *Hybopsis dissimilis* and *Labidesthes sicculus*. Claytor Lake, Bluestone Reservoir and the Union Carbide impoundment at Hawks Nest may be barriers for downstream dispersal of upper New River fishes (Ross 1959; Ross and Perkins 1959; Hambrick et al. 1973; Jenkins et al. 1972; Hocutt 1974; Hocutt et al. 1978; and Stauffer 1975). While the complete effectiveness of Kanawha Falls as a barrier to the upstream dispersal of fishes from the lower Kanawha River is debatable (Hocutt, in press), it no doubt is a limiting factor for many species.

Table 2. Number of each species collected from Gauley River, 1976, by station. (*new literature records to the Gauley River ichthyofauna; **first literature records for species above Kanawha Falls).

Species	Stations 1	2	3	4	5	6
**Lampetra aepyptera					1	
*Anguilla rostrata						1
*Salmo gairdneri						
*S. trutta						
Salvelinus fontinalis						
Campostoma anomalum			3			
Clinostomus funduloides						
Ericymba buccata				1		4
Exoglossum laurae						
Nocomis platyrhynchus		8	35	11	7	10
*Notemigonus crysoleucas						1
*Notropis albeolus			13			1
*N. chrysocephalus					106	
N. photogenis				2		
N. rubellus			57	333	383	4
N. scabriceps						
N. stramineus						
*N. telescopus						
N. volucellus				86	21	974
Phenacobius teretulus						
Pimephales notatus			22	195	40	494
*P. promelas						
Rhinichthys atratulus	21	24		2		
*R. cataractae		3			2	1
Semotilus atromaculatus	5	12				3
Catostomus commersoni					3	18
Hypentelium nigricans		3	5	10	1	18
**Moxostoma erythrurum						
**Ictalurus natalis						
**I. nebulosus						
**Noturus flavus						
*Pylodictus olivaris						
Ambloplites rupestris			2	7		3
*Lepomis cyanellus						
*L. gibbosus						
L. macrochirus						1
Micropterus dolomieui				6	2	25
*M. punctulatus						
*M. salmoides						
Etheostoma blennioides			30	11	1	3
*E. caeruleum						
E. flabellare	17	10	4		1	
*E. nigrum					3	162
E. osburni	1		15	2	3	
**Percina caprodes						
P. maculata			3			
*P. oxyrhyncha				2		1
Stizostedion vitreum						
*Cottus bairdi						
*C. carolinae						
Total Species	4	6	11	13	14	17
Total Specimens	44	60	189	668	574	1723

Table 2. (Cont.)

Species	Stations 7	8	9	10	11	12
****Lampetra aepyptera**						
***Anguilla rostrata**						
***Salmo gairdneri**				2	1	
***S. trutta**						
Salvelinus fontinalis						
Campostoma anomalum	2	9	10	2	2	1
Clinostomus funduloides						
Ericymba buccata			32			
Exoglossum laurae					5	
Nocomis platyrhynchus	39	67	18		7	11
***Notemigonus crysoleucas**						
***Notropis albeolus**		58	36			
***N. chrysocephalus**					1	1
N. photogenis		25	50		1	
N. rubellus	1	108	243			12
N. scabriceps						1
N. stramineus			180			
***N. telescopus**		15				
N. volucellus		5	93			
Phenacobius teretulus						
Pimephales notatus	2	10	16	1	31	
***P. promelas**				14		
Rhinichthys atratulus				38	9	
***R. cataractae**	27	91	4	1	1	
Semotilus atromaculatus				40	8	1
Catostomus commersoni			5	118	3	
Hypentelium nigricans	14	10	36	2	1	
****Moxostoma erythrurum**						
****Ictalurus natalis**						
****I. nebulosus**						
****Noturus flavus**		8				
***Pylodictus olivaris**						
Ambloplites rupestris		1	4		6	1
***Lepomis cyanellus**						
***L. gibbosus**						
L. macrochirus						
Micropterus dolomieui	1	2	4		1	1
***M. punctulatus**			2			
***M. salmoides**						
Etheostoma blennioides	24	12	17		33	16
***E. caeruleum**		9	35			
E. flabellare		6	3	33	54	13
***E. nigrum**	39	2	1			
E. osburni		9	3	25		
****Percina caprodes**		4	10			
P. maculata					3	10
***P. oxyrhyncha**	4	30	6			
Stizostedion vitreum						
***Cottus bairdi**					3	
***C. carolinae**				3	10	
Total Species	10	20	22	12	19	11
Total Specimens	153	481	808	279	180	68

Table 2. (Cont.)

Species	Stations 13	14	15	16	17	18
**Lampetra aepyptera						
*Anguilla rostrata						
*Salmo gairdneri	1	1	1		4	
*S. trutta						
Salvelinus fontinalis	2					3
Campostoma anomalum					38	30
Clinostomus funduloides					6	
Ericymba buccata						
Exoglossum laurae	1				1	1
Nocomis platyrhynchus					22	10
*Notemigonus crysoleucas						
*Notropis albeolus						
*N. chrysocephalus						
N. photogenis					2	
N. rubellus						
N. scabriceps						
N. stramineus						
*N. telescopus						
N. volucellus						
Phenacobius teretulus					2	
Pimephales notatus						
*P. promelas						
Rhinichthys atratulus	19			20		89
*R. cataractae	4				9	2
Semotilus atromaculatus	1			1	1	21
Catostomus commersoni	1					9
Hypentelium nigricans					3	
**Moxostoma erythrurum						
**Ictalurus natalis						
**I. nebulosus						
**Noturus flavus						
*Pylodictus olivaris						
Ambloplites rupestris						
*Lepomis cyanellus						
*L. gibbosus						
L. macrochirus			5			
Micropterus dolomieui					2	
*M. punctulatus						
*M. salmoides			2			
Etheostoma blennioides						
*E. caeruleum						
E. flabellare	15	2			6	11
*E. nigrum		2				
E. osburni					7	7
**Percina caprodes						
P. maculata						4
*P. oxyrhyncha						
Stizostedion vitreum						
*Cottus bairdi						
*C. carolinae						
Total Species	8	3	3	2	12	12
Total Specimens	44	4	8	21	101	189

Table 2. (Cont.)

Species	Stations 19	20	21	22	23	24[1]
****Lampetra aepyptera**						
***Anguilla rostrata**						
***Salmo gairdneri**						
***S. trutta**				3		
Salvelinus fontinalis			2			
Campostoma anomalum	1	47		1		3
Clinostomus funduloides		1				
Ericymba buccata						
Exoglossum laurae						
Nocomis platyrhynchus		14				41
***Notemigonus crysoleucas**						
***Notropis albeolus**						
***N. chrysocephalus**		21				8
N. photogenis		1				
N. rubellus		81				10
N. scabriceps						
N. stramineus						
***N. telescopus**						
N. volucellus						
Phenacobius teretulus						
Pimephales notatus		1				
***P. promelas**						
Rhinichthys atratulus			98	32		2
***R. cataractae**		3				16
Semotilus atromaculatus			5	4	4	10
Catostomus commersoni				3	2	4
Hypentelium nigricans		16		3		9
****Moxostoma erythrurum**						4[1]
****Ictalurus natalis**						
****I. nebulosus**						
****Noturus flavus**						
***Pylodictus olivaris**						
Ambloplites rupestris		5				4
***Lepomis cyanellus**						
***L. gibbosus**						
L. macrochirus						
Micropterus dolomieui		4				
***M. punctulatus**						
***M. salmoides**						
Etheostoma blennioides		8		4		2
***E. caeruleum**						
E. flabellare		12	10	21	1	2
***E. nigrum**		11		2		
E. osburni		5				
****Percina caprodes**						
P. maculata				4		1
***P. oxyrhyncha**						
Stizostedion vitreum						
***Cottus bairdi**						
***C. carolinae**						
Total Species	1	15	4	10	3	13
Total Specimens	1	230	115	77	7	112

[1]***Moxostoma erythrurum* (AEL 226), four specimens collected in Summersville Reservoir at mouth of Hominy Creek by gill net in conjunction with this survey are not included in total number of species and specimens at Station 24.

Table 2. (Cont.)

Species	Stations 25	26	27	28	29	30
****Lampetra aepyptera**						
***Anguilla rostrata**						
***Salmo gairdneri**						
***S. trutta**						
Salvelinus fontinalis						
Campostoma anomalum					5	20
Clinostomus funduloides						
Ericymba buccata	4					
Exoglossum laurae						
Nocomis platyrhynchus						86
***Notemigonus crysoleucas**						
***Notropis albeolus**						
***N. chrysocephalus**						
N. photogenis						
N. rubellus				21	14	146
N. scabriceps						
N. stramineus						
***N. telescopus**						
N. volucellus						
Phenacobius teretulus						
Pimephales notatus	24	101	45	375	7	15
***P. promelas**						
Rhinichthys atratulus	54	2				
***R. cataractae**						1
Semotilus atromaculatus	7	2	50	6		
Catostomus commersoni	10	2	5	3	1	
Hypentelium nigricans						4
****Moxostoma erythrurum**						
****Ictalurus natalis**		1				
****I. nebulosus**						
****Noturus flavus**						
***Pylodictus olivaris**						
Ambloplites rupestris		2		2	1	24
***Lepomis cyanellus**	4	6		1		
***L. gibbosus**						
L. macrochirus				3		
Micropterus dolomieui						19
***M. punctulatus**	1			5		
***M. salmoides**						
Etheostoma blennioides				1	7	3
***E. caeruleum**						
E. flabellare		4	1			
***E. nigrum**						15
E. osburni	5					
****Percina caprodes**						
P. maculata						
***P. oxyrhyncha**						8
Stizostedion vitreum						
***Cottus bairdi**						
***C. carolinae**						
Total Species	7	8	4	9	6	1
Total Specimens	104	120	101	417	35	341

Table 2. (Cont.)

Species	Stations 31	32	33	34	35	36
****Lampetra aepyptera**						
***Anguilla rostrata**						
***Salmo gairdneri**				15		10
***S. trutta**						1
Salvelinus fontinalis	1					
Campostoma anomalum	2	7	2	1		
Clinostomus funduloides						
Ericymba buccata	4	1		3	2	
Exoglossum laurae						
Nocomis platyrhynchus	9	251	188	5	2	
***Notemigonus crysoleucas**						
***Notropis albeolus**					9	
***N. chrysocephalus**						
N. photogenis						
N. rubellus	110	20	14	16	39	
N. scabriceps						
N. stramineus						
***N. telescopus**						
N. volucellus						
Phenacobius teretulus						
Pimephales notatus	4	11	6	85	150	
***P. promelas**						
Rhinichthys atratulus	1			8		24
***R. cataractae**		54	99			
Semotilus atromaculatus	24	2	1	19	6	6
Catostomus commersoni	5		1		1	
Hypentelium nigricans	2	77	16	5	1	
****Moxostoma erythrurum**						
****Ictalurus natalis**						
****I. nebulosus**				1		
****Noturus flavus**						
***Pylodictus olivaris**			5			
Ambloplites rupestris	1	8	28	3	1	
***Lepomis cyanellus**				7	11	
***L. gibbosus**						
L. macrochirus						
Micropterus dolomieui	1	72	41			
***M. punctulatus**						
***M. salmoides**						
Etheostoma blennioides	1	3	14			
***E. caeruleum**						
E. flabellare	5			10	1	1
***E. nigrum**	1		7			
E. osburni						
****Percina caprodes**						
P. maculata						
***P. oxyrhyncha**		24	54			
Stizostedion vitreum			1			
***Cottus bairdi**						
***C. carolinae**						
Total Species	15	12	16	13	11	5
Total Specimens	171	530	478	178	223	42

Table 2. (Cont.)

Species	Stations 37	38	39	40	41	42
**Lampetra aepyptera						
*Anguilla rostrata						
*Salmo gairdneri						
*S. trutta						
Salvelinus fontinalis						
Campostoma anomalum		17		7		225
Clinostomus funduloides		83	17	3		
Ericymba buccata	33	5	12	18		40
Exoglossum laurae						
Nocomis platyrhynchus				1		15
*Notemigonus crysoleucas						
*Notropis albeolus						1
*N. chrysocephalus						
N. photogenis						7
N. rubellus	7					26
N. scabriceps						
N. stramineus						
*N. telescopus						
N. volucellus						
Phenacobius teretulus						
Pimephales notatus	109	4		166		33
*P. promelas						
Rhinichthys atratulus	2	1	8	2	1	22
*R. cataractae						
Semotilus atromaculatus	15	11	23	32	29	211
Catostomus commersoni	7	5	9	9	3	526
Hypentelium nigricans	1	1				32
**Moxostoma erythrurum						
**Ictalurus natalis						
**I. nebulosus						
**Noturus flavus						
*Pylodictus olivaris						
Ambloplites rupestris	2			3		
*Lepomis cyanellus	1					
*L. gibbosus	1					
L. macrochirus						
Micropterus dolomieui		1		2		3
*M. punctulatus						
*M. salmoides						
Etheostoma blennioides		1		2		5
*E. caeruleum						124
E. flabellare		1	37			
*E. nigrum						21
E. osburni						
**Percina caprodes						
P. maculata						
*P. oxyrhyncha						
Stizostedion vitreum						
*Cottus bairdi						
*C. carolinae						
Total Species	10	11	6	11	3	15
Total Specimens	178	130	106	245	33	1291

Table 2. (Cont.)

Species	Stations 43	44	45	46	47	48
****Lampetra aepyptera**						
***Anguilla rostrata**						
***Salmo gairdneri**						
***S. trutta**						
Salvelinus fontinalis						
Campostoma anomalum						2
Clinostomus funduloides						
Ericymba buccata		67	14			24
Exoglossum laurae						
Nocomis platyrhynchus						
***Notemigonus crysoleucas**		2				
***Notropis albeolus**						
***N. chrysocephalus**						
N. photogenis					1	
N. rubellus						45
N. scabriceps						
N. stramineus						1
***N. telescopus**						
N. volucellus						
Phenacobius teretulus						
Pimephales notatus		100	21			52
***P. promelas**						
Rhinichthys atratulus	1					
***R. cataractae**						
Semotilus atromaculatus	69	10			11	8
Catostomus commersoni	19	1			2	
Hypentelium nigricans		1				2
****Moxostoma erythrurum**						
****Ictalurus natalis**						
****I. nebulosus**						
****Noturus flavus**						
***Pylodictus olivaris**						
Ambloplites rupestris				2		
***Lepomis cyanellus**	1		2			
***L. gibbosus**						
L. macrochirus	4					
Micropterus dolomieui				3		
***M. punctulatus**			1			
***M. salmoides**	1	1				
Etheostoma blennioides		1		2		
***E. caeruleum**						
E. flabellare	1			3		
***E. nigrum**						
E. osburni						
****Percina caprodes**						
P. maculata						
***P. oxyrhyncha**						
Stizostedion vitreum						
***Cottus bairdi**						
***C. carolinae**					12	4
Total Species	7	8	4	4	4	8
Total Specimens	96	183	38	10	26	138

Table 2. (Cont.)

Species	Stations 49	50	51	52	Total
****Lampetra aepyptera**					
***Anguilla rostrata**					
***Salmo gairdneri**					
***S. trutta**					
Salvelinus fontinalis					
Campostoma anomalum	7	24	33	5	
Clinostomus funduloides					
Ericymba buccata	33	92	55	15	
Exoglossum laurae					
Nocomis platyrhynchus		4			
***Notemigonus crysoleucas**					
***Notropis albeolus**		107	5	13	
***N. chrysocephalus**					
N. photogenis		15	4		
N. rubellus	102	42	92	7	
N. scabriceps					
N. stramineus	23	5	4	13	
***N. telescopus**		1			
N. volucellus				1	
Phenacobius teretulus					
Pimephales notatus	75	43	9	9	
***P. promelas**					
Rhinichthys atratulus					
***R. cataractae**			1	1	
Semotilus atromaculatus	9	16	20		
Catostomus commersoni	18			1	
Hypentelium nigricans	89	14	1	7	
****Moxostoma erythrurum**					
****Ictalurus natalis**					
****I. nebulosus**					
****Noturus flavus**					
***Pylodictus olivaris**					
Ambloplites rupestris			1		
***Lepomis cyanellus**					
***L. gibbosus**					
L. macrochirus					
Micropterus dolomieui	22	5	2	2	
***M. punctulatus**				1	
***M. salmoides**					
Etheostoma blennioides		2	3	1	
***E. caeruleum**		8	91	5	
E. flabellare		2	4	1	
***E. nigrum**				2	
E. osburni					
****Percina caprodes**					
P. maculata					
***P. oxyrhyncha**					
Stizostedion vitreum					
***Cottus bairdi**					
***C. carolinae**					
Total Species	9	15	15	16	49
Total Specimens	378	380	325	84	12,518

ZOOGEOGRAPHY

This survey established many distributional records. The remoteness of the drainage and its inaccessibility, particularly in the lower two-thirds of the main-stem and its tributaries, has undoubtedly been a deterrent to sampling. The upper New River is generally more accessible. Perhaps for this reason, students of West Virginia fishes have tended to avoid the Gauley in their efforts.

The confluence of Gauley and New rivers forms Kanawha River above Kanawha Falls, long considered to be a barrier to upstream dispersal of fishes. All the endemic forms of the upper Kanawha (New) drainage occur in the Gauley, exluding *Etheostoma kanawhae* which is not known from West Virginia. However, the presence of six species found in Gauley River in this survey and not previously reported from the upper Kanawha drainage infers a relationship of the Gauley with the lower Kanawha drainage. The new distributional records indicate that either Kanawha Falls was not as effective a barrier as supposed, or conditions were once more favorable than at present for the dispersal of fishes above the Falls into Gauley River. In either case, it is assumed that other physical barriers were effective in limiting dispersal of fishes into the upper New River system. The zoogeographic relationships summarized below are discussed in detail by Hocutt (in press).

The wide distribution of *Etheostoma nigrum* in the Gauley drainage supports a hypothesis that more favorable conditions once existed for fishes to negotiate Kanawha Falls. It is more often found in slack water habitats over sand and detritus, and avoids strong currents. Thus, we reason that it is not a recent migrant over Kanawha Falls. Cole (1971) supports this, postulating that the present *E. nigrum* distribution resembles that of pre-Pleistocene times, and that populations east of the Appalachians are a consequence of relatively recent stream capture.

Subsequent to the Tertiary uplift of the Appalachians, the Teays River had a cutting advantage due to its volume and gradient. The evolving (New River) gorge with its multitude of rapids and cataracts probably served as an effective barrier. Kanawha, Wylie, Bull and Sandstone Falls are remnants of that rejuvenated period (Hocutt et al. 1978). Prior to recent impoundment, Kanawha Falls was the first of the series of natural barriers that served as a faunal filter (Hocutt in press).

The Pleistocene (Neff et al. 1970; Hocutt et al. 1978) impoundment of Teays River would have inundated Kanawha Falls if indeed the Falls existed at that time. Gauley River, smaller in drainage and volume of water, cut its gorge more slowly than the Teays and offered a route of dispersal for fishes (Hocutt, in press). Many species present today serve as relict populations to that time. The large numbers of *Etheostoma caeruleum*

support the contention that conditions once facilitated passage of fish upstream of the Falls area. *Lampetra aepyptera, Moxostoma erythrurum, Ictalurus natalis, I. nebulosus,* and *Noturus flavus* are native to the greater Ohio River drainage (Jenkins et al. 1972), thus their presence in the Gauley system may be explained by a Pleistocene impoundment. The capture of an immature *L. aepyptera* above Summersville Dam suggests a population predating construction; the presence of *N. flavus* in a 1951 collection (CU 32540) is similar evidence for an established population.

Gilbert (1969) regarded *Notropis telescopus* as introduced to the New River system, with all previously known records being very recent and from only a small part of the upper New River, Virginia (Jenkins et al. 1972). Subsequently, it was collected by Hocutt et al. (1978) from Greenbrier River, West Virginia, in this survey, and from Kanawha River below Kanawha Falls (Hocutt and Stauffer, ms). These data suggest three alternatives for its distributional status: (1) it is indeed an introduced species to the upper New system that has rapidly extended its range downstream by negotiating Bluestone Reservoir and the Union Carbide impoundment at Hawks Nest; (2) it is an introduced species to both the upper (New) and lower Kanawha drainages; or (3) it is a native species that is rarely encountered in the Kanawha drainage, its presence probably related to stream capture with the Tennessee drainage (Ross and Carico 1963).

Notropis scabriceps and *Phenacobius teretulus* are identified as part of the unique faunal assemblage of New River. Their almost exclusive distribution in the upper Gauley River system could be related to stream piracy with Greenbrier River (Wright 1934; Hocutt, in press), or to present-day ecological factors limiting their distribution. Wright (1934) felt there was evidence that the East Fork of Greenbrier River and Knapp Creek at one time continued a westerly flow beyond the present Greenbrier. The East Fork would have joined Shavers Fork in the vicinity of Cheat Bridge. Knapp Creek's westernly continuation is in approximate alignment with Stony Creek (reversed) into Laurel Creek of Williams River (Gauley system). Wright (1934) stated that little geological evidence existed to support this contention in light of the fact that erosion of the Greenbrier Valley limestone erased traces of stream diversion. Biological evidence (Hocutt et al. 1977, 1978; Hocutt, in press) supports Wright's (1934) hypothesis. Additionally, if his contention were correct, dispersal of upper New River fauna (e.g., *N. scabriceps, P. teretulus, Cottus* spp.) into the Gauley system via Greenbrier River would have been possible.

Once fauna entered Gauley River via Williams River from the Greenbrier, distribution would be related to downstream and lateral dispersal. Little Beaver Creek may once have flowed into Muddlety Creek via

Harris Fork of the latter (Reger 1921). Peters Creek apparently captured Muddlety Creek drainage via Arbuckle Branch, and could have once flowed through the present valleys of Otter and Little Elk creeks to a confluence with Gauley River at Swiss, 12. 9 km downstream of its present mouth (Reger 1921). Back Fork of McMillion Creek may have once flowed into Persinger Creek. Similarly, fishes may have dispersed upstream through this series of captures.

Elk River of the lower Kanawha drainage has captured part of the Gauley system (Campbell 1896) and continues to encroach on Gauley River waters. Only 4.8 km separate their main-channels near Webster Springs, and capture by the Elk appears imminent (Reger 1920); the Elk valley is nearly 244 m lower than the Gauley valley at Webster Springs. Also, Anthony and Laurel creeks, tributaries to Birch River of the Elk system, are presently encroaching on Beaver and Muddlety creeks of Gauley River (Reger 1921). There may have been faunal interchange during the Elk River capture of Gauley River drainage (Campbell 1896). *Noturus miurus* (UNC 7629; identifications verified) is recorded from Williams River (Gauley system), but is suspected to represent a mistaken locality. No specimens were collected by us from Williams River after repeated sampling, but the species is known from nearby Elk River (Taylor 1969).

In summary, these data support a hypothesis that Kanawha Falls was once more navigable to fishes than at present (Hocutt, in press). Ichthyofauna once above the Falls area could migrate up either the New River gorge and its series of montane stresses, or up Gauley River, a rigorous but less stressful route. Biological evidence supports Wright's (1934) contention of piracy between the Greenbrier and Gauley rivers, with fauna having dispersed into each drainage from the other. Facts may be masked by introductions of various species (e.g., Hocutt and Hambrick 1973) into the Gauley system, and by extensive logging and mining operations in the basin during the past 80 years.

ACKNOWLEDGMENTS. — We particularly wish to express our gratitude to D. Harris, C. Clower and W. Tolan of the Ecological Services Division, U.S. Fish and Wildlife Service, Elkins, West Virginia. The spirit in which this study was conducted is a tribute to their cooperation. Our appreciation is further extended to various persons of the West Virginia Department of Natural Resources (W. Va. DNR) who assisted whenever possible and directed the rotenone samplings. Also, we are appreciative of the Handley and Elkins facilities which the W. Va. DNR allowed us to use during the course of this investigation. Fred C. Rohde, University of North

Carolina, Morehead City, confirmed the identification of *Lampetra aepyptera*. Drs. David A. Etnier, University of Tennesee, and Robert E. Jenkins, Virginia Commonwealth University, offered critical comment for improvement of the manuscript.

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Accepted 27 June 1978

Historical Review of the Carolina Parakeet in the Carolinas

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ABSTRACT. — Parrots or parakeets appear in many lists of Carolina birds recorded by such early voyagers, explorers and promoters as Thomas Hariot (1588), William Hilton (1664), Thomas Ashe (1682), Samuel Wilson (1682), John Lawson (1709), Mark Catesby (1731) and others. These references, when authentic, can be safely assigned to the now extinct Carolina parakeet, *Conuropsis carolinensis*. The species was so named by Linnaeus (1758) from a drawing of a specimen taken in South Carolina by Catesby. Despite association of the region with the bird's name, a long history constitutes the bulk of evidence on the species in the Carolinas. There are no specimens, exceedingly few precise claims by ornithologists, and no specific references to eggs, migratory movements or young. Little can be found to validate North Carolina's claim to parakeets after about 1770 (William Bartram). For South Carolina, matters are more complex: widely spaced but fairly persistent records bring the bird's history there down to about the end of the Civil War, with a final, no doubt storm-tossed, bird accidentally occurring about 1885. There was a flurry of alleged sightings in the decade of the 1930s, but the birds either disappeared without documentation or were not there in the first place.

INTRODUCTION

In an account of the Carolina parakeet, *Conuropsis carolinensis* (Linnaeus), history and biology must mix, for the species is extinct. That notably handsome bird, so often remarked by early travelers, thus joins the passenger pigeon and other vanished species in a group about which we (as a civilization) know pretty much all that we shall know. Veteran ornithologists know about it, of course, and sometimes allege a good many things that a careful historian of the species learns are not true. But, ask a concerned American citizen to name ten exterminated species of animals and the Carolina parakeet will probably not be among them.

Except for its name, the parrot of Carolina was not uniquely associated with the Carolinas. It was widely, if somewhat erratically, distributed in the eastern United States, being found from Florida to Texas and well up the Arkansas, Missouri, Ohio and Mississippi river valleys. This report, emphasizing evidence on distribution in North and South

Carolina, extends my geographical history of the parakeet (McKinley 1960, 1964, 1965, 1976, 1977a, b, c, 1978a, b, c). Some quotations from the literature may seem unnecessarily long, but they impart to modern readers the enormous impact made by the new land upon early observers, and leave to critical minds the final evaluation of these pioneer statements.

Early and late, there is chaff among the grain. Since "Carolina" already has an open-ended quality about it, for example, it may be well to sandwich in here a quaint and innocent early allusion to the parakeet in the New World, although largely extrapolated from the cartographic. Except for Hariot's Roanoke Island report for North Carolina, it is also the earliest attribution of the species to the area of Carolina. Sanson d'Abbeville, writing about 1653, said nothing about parakeets in Florida or Virginia, but in regard to a vague region in between that he called (in translation) "the Appalachians," he wrote: "In this region there are parrots, pigeons, turtle doves, eagles, ducks, magpies, sparrows and many other types of birds:" A map accompanying his account shows an inland area denominated "Apalatchy Monts" which runs more or less east-west between a tremendously northerly-swollen Florida and a Virginia that is sort of hunched up against the Atlantic Ocean (1959:48).

PARAKEETS IN NORTH CAROLINA: THE REPORTS

For a state with few substantial records of the parakeet, North Carolina has a history of the species that is resplendent in its antiquity. Thomas Hariot (1588) reported that the ill-starred little colony on Roanoke Island had parrots. In what was certainly America's first example of science for science's sake, he wrote: "There are also Parats, Faulcons & Marlin haukes, which although with us they bee not used for meate, yet for other causes I thought good to mention" (in Quinn 1955:359). Unfortunately, John White, dedicated planter of the colony (and grandfather of Virginia Dare, born there), did not figure the parakeet among the lovely illustrations of natural history subjects that he left to a careless posterity (Hulton 1965).

Thus, Dare County has an early claim to parakeets. The next report affirmed that the species was found in southeastern parts of the state. Captain William Hilton of the West Indian island of Barbados carefully surveyed the coast of the Carolinas in autumn 1663. His explorations of Cape Fear River may have taken him to the vicinity of Fayetteville, Cumberland County, with noteworthy descriptive results. In early November, he described the return down-river toward the sea (1664): "So we returned . . . viewing the Land on both sides the River, and found as good tracts of land, dry, well wooded, pleasant and delightful as we have seen any where

in the world, with great burthen of Grasse on it, and in some places very high, the woods stor'd with abundance of Deer and Turkies every where; we never going on shoar, but saw of each also Partridges great store, Cranes abundance, Conies, which we saw in several places; we heard several Wolves howling in the woods, and saw where they had torn a Deer in pieces. Also in the River we saw great store of Ducks, Teile, Widgeon, and in the woods great flocks of Parrakeeto's; the Timber that the woods afford for the most part consisting of Oaks of four or five sorts, all differing in leaves, but all bearing Akorns very good." To certify that the expedition was not bent entirely upon esthetic and scientific ends, he enumerated the game taken: "In that time as our business called us up and down the River and Branches . . . we kill'd of wild-fowl, four Swans, ten Geese, twenty nine Cranes, ten Turkies, forty Duck and Mallard, three dozen of Parrakeeto's, and six or seven dozen of other small Fowls, as Curlues and Plovers, etc." (Salley 1911:46, 53). The decimation of a continent was underway.

But, such early writers served their own days only, if any at all, and seem to have been soon forgotten. More seminal, however, was the work of John Lawson, loyal adopted son of North Carolina. I think it probably significant that he left no evidence of having seen parakeets in the arduous journey from Charleston, South Carolina, to Pamlico Sound, North Carolina, in the period of late 1700 to late February 1701. That trip took his party up the Santee River and its tributary, the Wateree, to the vicinity of Union County, North Carolina. From there they went northward deep into central parts of the latter state, thence eastward to coastal "Pamptico-cough" (Pamlico), a distance of some 550 miles (see Lefler's comments, Lawson 1967).

Lawson's 1709 account of the aboriginal and natural history of the colony of North Carolina has extensive accounts of many kinds of animals and plants, including parakeets. It is full of information — and misinformation — that must have cost him much conversation and correspondence. "Parrakeetos are of a green Colour, and Orange-Colour'd half way their Head," he wrote in part. "Of these and the Allegators, there is found none to the Northward of this Province" (1967:146-147).

Colonel William Byrd of Westover, ever in search of an outlet for his restless energies (and of a source of income) had something to say about parakeets in North Carolina. He had little use for the scurvy inhabitants of that state, but mentioned as an extenuating circumstance in their failure to plant orchards that "paraqueets" frequently raided fruit trees in autumn (1929:77-78). Or so he said. I suspect the passage was put in for literary effect; his secret diary, from which he later wrote up the public account, does not mention the parakeets at all (*op. cit.*).

When Benjamin Franklin's printing partner, Hugh Meredith, grew tired of the bonds of city life, he dissolved the partnership (July 1730) and apparently went to live among Welch kinsmen that summer and fall near Cape Fear in Brunswick and New Hanover counties. He spent the winter at the mouth of Black River, South Carolina, "near 100 miles West of *Brunswick*." His letters to Franklin describing Cape Fear, published in April and May 1731, were presumably written that winter or early spring and, of course, refer to the previous summer. The Cape Fear region, Meredith reported, had no chestnut, but other Pennsylvania trees were present, plus "Cypress, Laurel, Bay red and yellow, Live Oak and Swamp Oak, all Evergreen except Cypress; with several Sorts whose Names I know not. Pheasants and Heath-hens here are none, but all other Fowl common with you are. Parraquets in Summer, and greater Plenty of Turkeys than ever I saw in Pennsylvania. Here are Foxes, Wolves, Wildcats, Possums, Raccoons, and Panthers always, and Bears sometimes in great plenty; also plenty of Deer, but Beavers here are none, nor any Ground-Squirrels, tho' plenty of Gray and Flying Squirrels; Alligators are very numerous here but not very mischievous; however, on their Account Swimming is less practis'd here than in the Northern Provinces" (1922:26-27). It is unfortunately not clear whether Meredith meant to say that parakeets were absent in winter. If we infer this, it must be realized that it would have been hearsay information in his case.

John Brickell, who practiced medicine in Edenton for many years, took part of his material straight from Lawson and added bits of his own. Whether to trust him at all is a question at times. For example, he observed in 1737, in regard to what he called "Black small-Crows" (by which he apparently meant blackbirds of some sort that were enemies of corn), that they "Build their Nest in hollow Trees as the *Parakeetoes* do" (1911:179, 181). This is something that our native blackbirds do not do and which is largely a matter of popular conviction with the parakeet, for nobody ever got around to observing it conclusively. (A source of additional Brickell claims is the Virginia traveler, the Rev. John Clayton, as shown by Simpson and Simpson [1977], although Clayton contributed nothing on the parakeet. The Simpsons reproduce [page 4] a plate that appeared in the 1737 edition of Brickell where a "Parekeetoe" is among the fairly recognizable denizens of Carolina.)

Aside from William Bartram's rather circumstantial contribution of 1791, the story of the parakeet in North Carolina very nearly ends with Lawson and Brickell. When Bartram wrote that the "parrot of Carolina, or Parrakeet" was among "natives of Carolina and Florida, where they breed and continue the year round," North Carolina, although not expressly said, was probably meant. He had spent a good deal of the time

from 1761 to 1765 and 1770 to 1772 at the plantation of his uncle William who lived near present-day Council, Bladen County, in the Cape Fear River country. He wondered that parakeets did not appear in his native Pennsylvania, since they could, he thought, easily fly from North Carolina, "where they are very numerous" (1958:182, 190-191).

In a search of literature lasting nearly 20 years I have found no records of parakeets in the inland central and western three-quarters of North Carolina. Negative reports are never of much value singly, although I have cited Lawson's account above. I am also impressed by such a diary as that of Lieutenant Reeves, an intelligent Revolutionary War soldier of the Pennsylvania Line (1897). He crossed the entire central North Carolina region from north to south in the spring of 1782, alert to all natural phenomena, but saw no parakeets until he was within South Carolina.

NORTH CAROLINA: A CRITIQUE OF RETROSPECTS

Considering enormous geographic differences between North and South Carolina, it is unfortunate that even ornithologists have so often lumped them as "the Carolinas." It is certainly doubtful if a statement that, "They apparently were common in the Carolinas up to 1850, or perhaps 1860, but must have disappeared from there soon after that" (Bent 1940:3) ought to stand as any sort of North Carolina record. H. H. Brimley wrote that the Austro-riparian or Louisianian Life Zone, characterized by the alligator, marsh rabbit, big eared bat and chuck-will's-widow, "formerly . . . received added brilliance in North Carolina by the presence of the gaudy and noisy Carolina Parroquet," but he offered no significant evidence of its occurrence (1896:66). C. S. Brimley had been asked by old people "what was the bird that used to roam over the state before the Civil War and eat cocklebur," but this is not satisfactory proof of its existence or time of disappearance (MS. note, N. C. State Museum).

The first state-wide bird list described the species as among those gone from North Carolina due to "changes in their environment," an instance of misplaced precision if there ever was one. No doubt optimistically, it was thought that the species might still be looked for as an accidental visitor in southeastern parts of the state (Atkinson 1887:50, 65).

Being totally unhelpful, both Hasbrouck (1891:374) and Smithwick (1897:212) cited Catesby as the only previous authority for the parakeet in North Carolina, despite the fact that Catesby did not refer to that state (Wayne 1917:3). Pearson et al. also mentioned "Catesby's record in 1731" (1919:184), adding to its geographic ambiguity the fact that the date was the rather belated year of publication, not the time when he

would have seen them there anyway. They later added William Byrd's so-called record (1942:192). They chose to ignore, no doubt wisely, a manuscript note dated 10 January 1925 that C. S. Brimley had filed in the State Museum: "Mr. John Handy Ford of Wilmington told Mr. J. C. Crawford recently that he took the eggs of this species some ten years ago in the swamps near Wilmington."

THE PARAKEET IN SOUTH CAROLINA: EARLY YEARS

References that call the parakeet a "formerly abundant permanent resident" (Bent 1940:3) and "common in the Carolinas up to 1850" (Sprunt and Chamberlain 1949:292) are rather devoid of substantiating details. Elliott Coues, in the first critical list of South Carolina birds, wrote that the species "appears to have been in former times a common bird: but its occurrence has not been noted of late years" (1869:119). But that, except for the negative second part, is also empty. Even Wayne's ambitious ornithology of the state provided an account that was obscure and lacking in details (1910:10). Bent mentioned the range of the parakeet as formerly including the Pine Barrens and Edding Island (1940:10), but both these attempts to particularize distributions require qualification, as will be shown.

The story of the parakeet in South Carolina begins modestly enough. "T. A., Gent." (supposedly Thomas Ashe, "Gentleman," a ship's clerk — and not a man named "Gent") included a list of birds in a promotional letter written to a friend, as was done by many early English explorers and exploiters. He described in glowing terms the region of "Charlestown," where he lived, probably about 1680-1682: "Birds the Country yields of differing kinds and Colours: For Prey, the Pelican, Hawk, and Eagle, etc. For Pleasure, the red, copped and blew Bird, which wantonly imitates the various Notes and Sounds of such Birds and Beasts which it hears, wherefore, by way of Allusion, it's call'd the mocking Bird; for which pleasing Property it's there esteem'd a Rarity. Duck, Mallard, Widgeon, Teal, Curlew, Plover, Partridge, the Flesh of which is equally as good, tho' smaller than ours in England. Pigeons and Parakeittoes. In Winter huge Flights of wild Turkies, oftentimes weighing from twenty, thirty, to forty pound . . . They have a Bird I believe the least in the whole Creation, named the Humming Bird; in bigness the Wren being much Superior . . . they continue between the Tropiques the whole year round . . . but I am informed, that in the more Northern parts of America they sleep the whole Winter" (Salley 1911:151-152). Although the worthy clerk perhaps got painted buntings ("red, copped and blew") confused with mockingbirds and his typesetter put "In Winter" with turkeys instead of parakeets, he ought not to be ridiculed for believing that various small birds hiber-

nated; many scientists of his day agreed with him. The year 1682, one judges, was a good one for wild turkeys, and the frontier mentality has fervently abided by forty-pound turkeys ever since.

Samuel Wilson, who was probably never in the colonies, seconded the sterling hopes of economic opportunities promoted by T. A., Gent. (and may even have purloined his bird list from that, or a common, source). Putting a Pounds-Shillings-Pence sign on everything that he could, he listed trees, other plants, fruits, mammals and birds found in the Charleston area: "Here are also in the woods great plenty of wilde Turkeys, Partridges, something smaller than those of England, but more de[l]icate, Turtle Doves, Paraquetos, and Pidgeons: On the grass planes the whistling Plover and Cranes and divers sorts of Birds unknowne in England." He also listed a number of waterfowl (1682; Salley 1911:170-171).

John Lawson, as I have already noted, did not mention parakeets in his long trip inland from Charleston in the winter of 1700-1701, suggestive negative evidence that the "Carolina" part of the bird's name was never more than a formality. It remained for his near-contemporary, visiting naturalist Mark Catesby, to put South Carolina's claim to the parakeet firmly on record (1731:11) and, incidentally, to bring it to attention of the scientific world. The latter event came to official fruition through the restless genius of the great Karl von Linné, known to the Latin-mongering elite of that time as Carolus Linnaeus. Linnaeus merely cited the species' homeland as "Carolina" and duly provided it with an enduring specific scientific name that says, in Latin, the same thing (1758:97). He said very little more, for he had not a specimen but only Catesby's plate and account from which to elaborate upon his legitimate binominal for the species. That Catesby referred to South Carolina only needs to be repeated; he did not mean to include North Carolina (Wayne 1917:3; consult also Catesby's places of residence in America: Frick and Stearns 1961). As to the status of the species, Catesby was sketchy and it is not clear whether he meant to imply that the species left Carolina twice a year, in winter and again, as the French naturalist Buffon put it, "in the love season," to reappear later in the season of harvest (Buffon 1792-1793:235-237). (Buffon was often misled by what he called the voice of reason — actually, his own preconceptions — and not only had no qualms about demoting New World forms to poor relations of Old World species, but also held firmly to his decision that parrots only bred in the tropics: hence, the Carolina parrot by simple calculation was but a migrant out of the French tropical colony of Guiana.)

Thomas Pennant, who, like Buffon, had not been in Carolina, wrote at first that "a few are found as far north as *Carolina*." He later amended that view to include Virginia, but considered it mainly a migratory bird even in

Carolina (1773:6; 1792, 1:282). Pennant's contemporary, John Latham, who became a universal genius in ornithology by taking uncritically from all previous authors, threw his net widely: "This bird inhabits Guiana, migrating into *Carolina* and *Virginia* in Autumn." He leaves one a little staggered by citing only Catesby for this monstrous combination (1781-1785:227).

In the midst of all this copying from each other, it is a pleasure to record observations of someone who actually saw a parakeet in "Carolina." The alert Lieutenant Enos Reeves marched southward into South Carolina in April 1782 and left a letter date-lined Congaree, Richland County, South Carolina, 20 April. In it he related intimate details of the back country. The countryside had changed dramatically after Charlotte had been reached and Rowan County, North Carolina, was crossed. His group approached McCord's Ferry on the Congaree River: "Here is the first place that I have come across the Palmetto tree or rather species of it called the Palmetto Royal and Parrots or rather Parroquetts, and I am told, that Alligators are to be found in this River" (1897:475-476).

William Bartram in 1791 offered first of all what everyone already knew or at least said often enough: parakeets "are natives of Carolina and Florida, where they breed and continue the year round." The "year round" part may refer to Florida alone and, more critical in this case, it is uncertain whether he meant to include South Carolina in his generalization, for his longest stays in Carolina were in North Carolina (1958:182, 190-191). In fact, although he seems to have had substantial personal knowledge of parakeets in North Carolina, this whole statement may simply be a bow to the Catesby tradition.

John Davis, an itinerant English tutor, spent autumn and early winter 1799 on the plantation of Thomas Drayton, apparently at Coosawhatchie, Jasper County. He went with his pupil on hunting forays: "we fired in vollies at the flocks of doves that frequent the corn fields; sometimes we discharged our pieces at the wild geese, whose empty cackling betrayed them; and once we brought down some paroquets that were directing their course over our heads to Georgia" (1909:91).

Robert Mills, an early historian of the state, included the "perroquet" in his statewide list, which included about 93 species; in county by county enumerations of birds that frequently repetitively included passenger pigeons, the only county specifically listed as having the "parroquet," as he spelled it the second time, was Beaufort County (1826:101,378).

Garrulous John James Audubon must also be cited. His genius for burying good observation amidst verbiage and glittering generality again asserted itself. In Volume II of his *Ornithological Biography* he told of keeping a couple of young black vultures in a coop in the yard, giving them "a

great number of Red-headed Woodpeckers and Parokeets, birds then easy to procure, as they were feeding daily on the mulberry trees in the immediate neighbourhood of my orphans" (1834:35). The area no doubt was Charleston, at the home of the Reverend John Bachman. An Audubon letter of 24 December 1833 mentions that vultures eat freshly killed birds and that this was the second experiment of this sort, being a repetition of what he, Audubon, had performed before (Herrick 1917, 2:55). Audubon had been at Bachman's place several times, but various circumstances indicate that the above events must have occurred during the visit that ended with his leaving Charleston in early June 1832, after he had spent the spring there. Both young black vultures and ripe mulberries would have been available in South Carolina before his departure. I am confident that this is a good South Carolina record of the parakeet and, despite its involved nature, perhaps more trustworthy than some claims, where literary effect or promotional advantage may be suspected.

Audubon's record is in fact the kind of first-hand, unstudied and spontaneous evidence so sadly lacking in the history of the parakeet (even in Audubon's own formal accounts). Memories are notoriously unreliable and yet end up being much of what little we have. Memories also become encrusted with information from sources quite removed from the original observations, if any. Samuel Scoville, Jr., an amateur ornithologist, visited South Carolina in May 1937. Conversation turned to parakeets (then alleged to be abroad in the state, as will be described later), and a landscape artist in Charleston related that his grandfather, born in the late 1830s, "used to tell of running out into his mother's garden in Charleston, when he was a little boy, to scare away the paroquets from the orange trees. Every year, too, he would ride over to Virginia Springs on his pony, while the rest of the family went in the family carriage, and on the way he would frequently see 'conures' — the Carolinian name for paroquets" (1940:560). The story may be true in the main; its date of around the 1840s seems acceptable, but I doubt seriously if Americans of that time would have called parakeets by the later pet-store name of "conure."

Scoville's date of around 1840 agrees with the memories of George Twiggs. He "was greatly interested in birds and . . . spent his boyhood on plantations in Aiken (South Carolina) and Richmond (Georgia) counties, and . . . died at the age of eighty in 1930." He "never observed this species . . . but . . . his father told him that they were not uncommon in Aiken County during his young manhood, about 1840" (Murphey 1937:24).

These memories place the species as present more or less into the

1840s. Plantation owner J. Motte Alston declared, however, that it had disappeared from the Santee River area (probably Georgetown County) "before my day" — he was born in 1821. His grandmother recalled large flocks of them, probably around 1780 (1953: 13). This dramatically uneven pattern of distribution, with vague allegations of previous abundance, seems to typify the parakeet over much, perhaps most, of its range. Any popular conjuration of it as a rival of the passenger pigeon's millions must be rejected out of hand.

Broome's attribution of breeding, year-round status to the parakeet in South Carolina was probably uncritical (1837:65). That in the hack historical work by Simms certainly was (1843:13). Ramsay's history considered the "perroquet" as permanent resident (1809, 2:185), as uninformative a remark as that of Professor Gibbes (1848:vi) who prepared a list that has been widely cited but which seems to have come straight out of Audubon's check-list of American birds (1839:189), even preserving Audubon's generic howler of *Centurus* for the parakeet.

A more reliable sounding record, on the other hand, has come down from Albert Twiggs, who had a long continued interest in natural history. As a 17-year old soldier "in the Confederate Army attempting unsuccessfully to stem Sherman's march from Savannah to Beaufort and Charleston . . . he had seen a number of flocks of paroquets on the Combahee River and in the pine woods between Yemassee and the coast, on numerous occasions" (Murphey 1937:24). The time of this observation can be calculated as late autumn 1864 and the place extreme southern South Carolina. It seems to be one of the last observations upon the species as a probably continuous resident in South Carolina, all other reports being at widely spaced intervals.

One of these later, perhaps accidental, appearances has been described for me by Jay Shuler (letter 1961). Dr. Eddie McClellan, an intelligent and interested observer, had recalled that a parakeet appeared after a big storm in 1885 and was killed with a slingshot in McClellansville, Charleston County. Since the species still existed in considerable numbers in parts of Florida at that time, such an occurrence is quite possible. But, it is also clear that there were no contemporary reports of parakeets in the South Carolina area. Witness Walter Hoxie's suggestion that "Parrot Ridge" on Edding Island, near Frogmore, Beaufort County, was "a name which designates many localities hereabouts and was doubtless bestowed by the early settlers when the gaudy Parrakeets flocked in this region" (1886). Hoxie was a talented and experienced ornithologist and he certainly had no first-hand knowledge of parakeets in South Carolina. His passing comment, more etymology than ornithology to begin with, was a poor reed for Bent to have leaned on in naming Edding Island a

former locality for the species in the state. No one seems to have documented Hoxie's claim that "many localities hereabouts" have the term "parrot" or "parakeet" in their names, and I cannot even precisely place his "Parrot Ridge."

Leverett M. Loomis, a careful student of ornithological history, turned up no surprises in his history of certain South Carolina birds, but perhaps was somewhat wide of the mark to place "the time of the disappearance of the Paroquet from our local fauna" as about 1826 (1886). But, his caution was commendable alongside the error of Hasbrouck (1891:374) who indicated that Waldo Irving Burnett listed the parakeet as present in the "pine barrens" in 1851. That unfortunate misfiring was heard round the world. Wayne (1910), Ridgway (1916), Pearson et al. (1919) and, as mentioned, Bent all allude to parakeets in the pine barrens, if not Burnett by name. Burnett's paper "On the fauna of the Pine Barrens of upper South Carolina" did indeed appear, as everybody's bibliography says, in 1851. It is a list of species observed, "with a few words on the 'conformability of individuals of the Fauna to each other' — whatever they may be," as Elliott Coues put it (1878:637). However, there is no reference to the Carolina parakeet in it.

The general failure of observers to leave definite records might justly be called Footnote Number One to the tragedy of the parakeet in South Carolina. Footnote Number Two came later. Paul M. Rea remarked editorially in 1919: "Tradition says that many years ago nearly a dozen Carolina Parrakeets were destroyed because they were not in sufficiently good condition to be exhibited. Some of these specimens undoubtedly lived in South Carolina. The Parrakeet is now almost extinct and it is not known that a single specimen from this state is in existence" (1919:7). "Tradition says" was no doubt just a polite way to avoid naming names and exposing someone to ridicule for the rashness of his action.

SOUTH CAROLINA: THE PRESENT CENTURY

Footnote Number Three to the parakeet in South Carolina may or may not have been a tragedy, for it may be that parakeets were not involved. Many real or alleged sightings of the Carolina parakeet have come in over the years. Nearly all such claims from the 1930s and 1940s, interestingly enough, were from South Carolina. It is from there, of course, that there came what, from sheer bulk of documentation, must remain the Gran'daddy of all "rediscoveries" of the parakeet. First, let me review summarily the body of published matter.

It all began when George M. Melamphy, working on a wild turkey project in the Santee Swamp, Georgetown County, talked to Alexander Sprunt, Jr., in 1933-1934, and reported several times seeing parakeets and

ivory-billed woodpeckers. The sighting of the latter rare species was finally fully substantiated, although the good news came to naught and the species could not be saved in that area. Sprunt and Chamberlain, in their study of South Carolina birds (1949: 292-293), later summarized the situation and the two authors fell neatly into two positions in the parliamentary arena, with Sprunt stoutly arguing for the Ayes.

In spite of, as will be seen, some equivocation by Robert P. Allen at the time (evident from Audubon Society records), his considered opinion in 1949 was that he had not seen parakeets (*op. cit.*: 294). Roger Tory Peterson also later confidently rejected the whole claim (1948:204, 207).

The contemporary published record is skimpy. John H. Baker, president of Sprunt and Allen's parent organization, the National Audubon Society, reported in *Bird-Lore* (1938) that there were no observations sufficiently definite to be considered scientific, although investigations would continue. The official pronouncement of the influential American Ornithologists' Union Protection Committee (1939) was negative. On the other hand, Samuel Scoville, Jr., an amateur bird-watcher, visited the Santee with some other people in May 1937 and managed to catch sight of a swiftly flying bird that appeared to him to be green in color (1940:564).

Although convinced that he had seen a parakeet, it was personal conviction alone for Scoville. *Time* magazine put it much more forcefully in a sensationalist note in 1941: "The Carolina parakeet . . . last reported seen in 1904 and long thought extinct, is not. Last week an official of the National Audubon Society confessed that a Charleston ornithologist has been watching parakeets in the Santee River swamps for five years." Actually, not many Audubon officials would have wanted their names associated with such a "confession" by that time. Revisionary hindsight, as has been shown above, even further eroded this ebullient pronouncement.

The ghost of the Santee parakeets, however, has not remained laid. George Laycock, field editor of *Audubon* (the modern name of *Bird-Lore*), has blown new life into the old drama of Santee Swamp, and thinks a negative conclusion less than scientifically proved (1969). No uncritical sensationalist, Laycock had just proved that even in zoos where the public record ought to have been straight from the beginning the parakeet lived three years longer than all the official textbooks said. The orthodox had their dates thoroughly mixed up, with misinformation from several sources congealing into the received version. As an example of how incorrect details accrue to an already dubious but popular conclusion, one report even had it that the region where the birds were allegedly sighted "has since been destroyed by a power project" (Greenway 1967:322) —

which is not quite the case, since the dams and reservoirs are considerably upstream from the area in question.

In discounting the discounters, Laycock convinced himself that there was some fire amidst all the smoke of the decade of the 1930s. Through the kindness of Les Line, editor of *Audubon*, I have read the very considerable amount of smoke generated in those faraway times. In the following review, I plan to quote from the Audubon Society archives only when some commentary upon the earlier published record or the good account by Laycock seems called for. Any apparent brusqueness is in the interest of brevity. The decision is still open and I leave the reader to his instincts.

George Melamphy, dismissed acidly by world famous ornithologist Ludlow Griscom as "not a bird student," did have some knowledge of wild turkeys and I can see no particular reason for him to mislead anyone in regard to other birds. Besides, he did apparently correctly alert Sprunt and others to the presence of ivory-billed woodpeckers. The preliminary report by Sprunt on 10 April 1935, relating definite but undated Melamphy sightings, described the region in question, some 25 miles above the delta of the Santee River, as "a tract of unbroken wilderness and absolutely virgin timber." His enthusiasm was probably justified, but Audubon official Lester L. Walsh on 24 December 1937 (after the chilling Griscom episode, to be recounted shortly) was more restrained in his analysis: "Lest any misapprehension exist relative to the extent of virgin timber let me say that most of the cypress and gum in the region gives indications of having been cut at one time or another." There were, however, unlumbered patches of small extent and some places judged adequate habitat for parakeets.

A "Cracker" (Sprunt's term) named W. F. "Red" Welch, who took on the very part-time job of warden for a section of the Santee tract over which the Audubon Society was able to gain slight control, also reported seeing a parakeet, but he may have been shoring up his job. He submitted a couple of feathers which looked interesting enough to Allen that he sent them to Alexander Wetmore of the U. S. National Museum for identification. Wetmore reported them to be meadowlark feathers.

Another local man, Warren J. Shokes (described as a man of "simple honesty" by Sprunt but who struck Griscom as "quite capable of bare fabrication") became official warden on 1 February 1936. He reported seeing a parakeet, with adult coloring, on 17 February. By the end of December he had reported five sightings of the parakeet, and on Christmas Day his son, Hollie, saw what Sprunt recorded as "a beautiful adult Carolina Paroquet." Hollie thought the bird had a rather darker band around the base of the neck than was shown in the picture given

him. By then, in their report for the period 26 November to 12 December 1936, both Sprunt and Allen had pretty much put their stamp of approval upon the notion that there were parakeets present. Despite Allen's later recantation, consider this: "From the details of these and previous observations and the established nature of the evening flyway we have no hesitation in identifying these birds as Carolina Paroquets (Conuropsis c. carolinensis)." It is perhaps not surprising that, in the face of such persnickity taxonomic overkill, talented and experienced Griscom should have emphasized that "neither gentleman had had any previous experience with wild parrots at any time or place."

Things slowed down in 1937. There was a February report of a parakeet from the elder Shokes but nothing else until 11 September when one was sighted. Shokes, with what seems to me a suspicious haggling over irrelevant — or spurious — details, insisted that there was some "'speckling'" around the shoulders of the latter bird, although agreeing otherwise that it was adult.

This time of lull was fated to coincide with the visit of top brass. Griscom and others descended in the period 7 to 16 December, during a stretch of bad weather. Griscom obviously was in a no-nonsense mood which, as a dean of American field ornithologists, he had some right to be. He pronounced it "most improbable that these birds were Carolina Paroquets; that they were more likely to be Parrots of other species that had escaped from captivity or been released." (It might have been questioned whether they were parrots at all.) Anyway, Griscom was concerned for the good name of the Society, should all that leak to the press, and he also wanted to keep investigations alive on the slim chance that something might turn up.

Some of Griscom's opinions of various people involved have been cited. It ought to be said that he considered the younger Shokes, Hollie, "a thoroughly honest and attractive fellow," although pretty largely lacking in critical capacities to make ornithological decisions. To exemplify his estimation Griscom pointedly noted that Hollie's sighting of what Sprunt had accepted as "a beautiful adult Carolina Paroquet" had, under grilling, become "a strange looking bird unlike anything he had ever seen before; that it was generally 'bluish in color with a yellow topknot,' and was apparently catching insects on the bank of the creek." Griscom suggested that "flight-lines" would not be held to by the birds over any very long period of time; that parrots were not usually late in going to roost (he might have pointed out that mourning doves, so like parakeets in size and perhaps even in pattern of flight, frequently careen about quite late); and that, even though he could be wrong about the Carolina parakeet, which he had never seen, parrots usually called and chattered loudly

when flying to feeding and roosting stations.

Evidently Hollie had failed to produce any birds on another visit by Sprunt in March 1938 (correspondence is missing). He did, allegedly with some reluctance, report to Sprunt in mid-November that he had seen parakeets in early June: two adults and what was presumably a young one "being taught to fly." The adults were reported to have raised quite a chatter. Sprunt thought this significant, for Hollie was "rather deaf, and . . . the noise made by the birds must have been considerable for him to hear it." Hollie had seen a lone adult — "One of those same birds" — on the first of September. He had reported neither incident to Sprunt spontaneously, not wanting to "stir up things again.'" By that time, however, the Shokeses were not in Audubon hire, the Santee Sanctuary had been discontinued, and Hollie was anxious to have employment.

What it all adds up to is difficult to calculate, but I find it hard to share Laycock's conclusion with enthusiasm. On the other hand, in the years since 1940 various reports of surviving parakeets have come to Sprunt and others. Nothing worthwhile ever evolved from any of them. It must be said, however, that nobody investigates them wholeheartedly — such reports are now filed (or referred) and forgotten. It is as if the hot potatoes and burned fingers of one generation deter those who come later from taking a chance.

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Accepted 27 November 1978

Estimates of Fish Populations in Two Northeastern North Carolina Swamp Streams

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ABSTRACT. — Fish populations were sampled in two northeastern North Carolina swamp streams, Duke and Hoggard Mill Creek, from May through August 1972. Water conditions permitted partitioning the streams into 0.4 km sections with nets, and estimating the abundances of 30 species in randomly chosen areas using the Petersen method. Some biomass estimates were also made. Population estimates in Duke Swamp varied from 6630 to 33,734 fish per surface hectare. In Hoggard Mill Creek estimated numbers ranged from 17,656 to 103,891 fish per surface hectare. Large variations were found in numbers of fish among sections of stream, but these variations were not uniform from species to species. Biomass estimates ranged from 195 kg to 1607 kg of fish per surface hectare for the two streams.

INTRODUCTION

Swamp streams are generally defined as streams located in lowland areas which flood periodically, inundating the vegetated flood plain for extended periods during the year. These areas are usually characterized by the presence of bald cypress, *Taxodium distichum*, and tupelo gum, *Nyssa aquatica*. The plant communities in these systems were described in detail by Wells (1928), Beaven and Oosting (1939), and Hall and Penfound (1943). Although swamp stream ecosystems are known to have diverse communities (Viosca 1928, Wharton 1970), few studies have been conducted regarding the abundance of their components.

Fish populations in two swamp streams were examined in this study from May through August 1972, in an effort to determine their composition and magnitude. Attempts were made to estimate the numerical abundance, and in some cases the biomass, of each species.

MATERIALS AND METHODS

THE STUDY AREA

Duke Swamp and Hoggard Mill Creek are swamp streams in Northeastern North Carolina (Fig. 1). Timber has been logged along both

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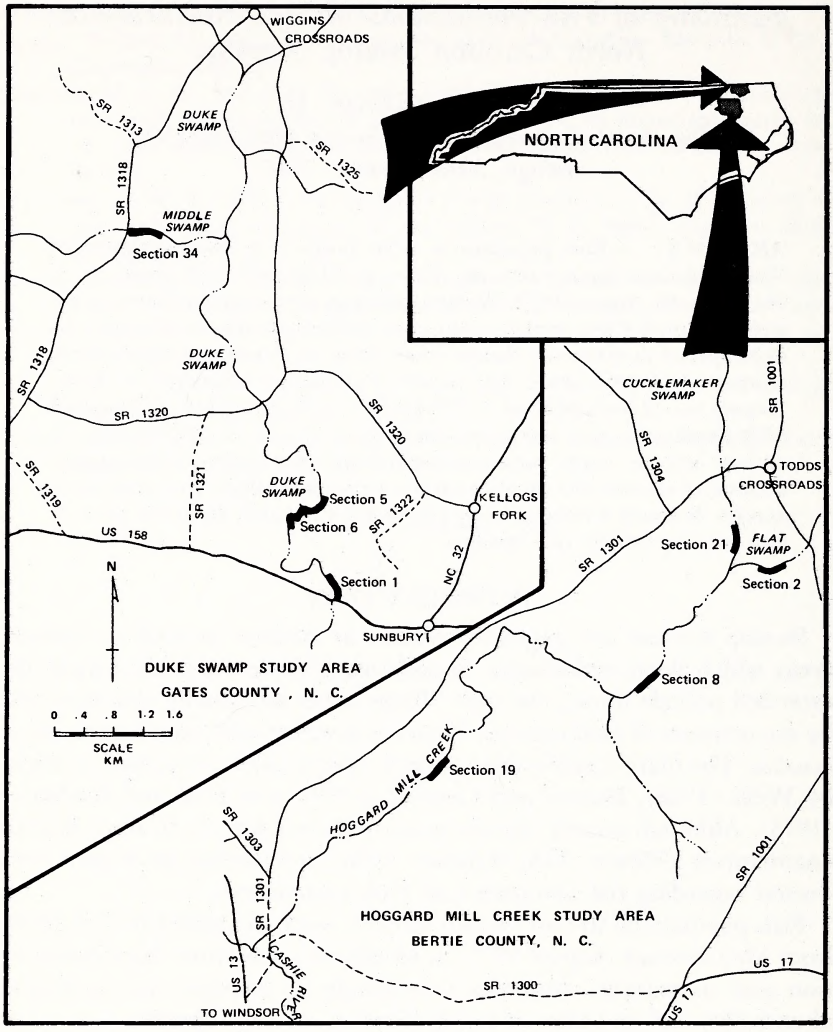

Fig. 1. Maps of Duke Swamp (upper left) and Hoggard Mill Creek (lower right) study areas, showing sampling sections.

streams but most areas have returned to the gum-cypress dominant forest type. In a few recently logged areas dense stands of aquatic vegetation and dense shrub layer have developed.

Approximately 13.7 stream km of Duke Swamp, a tributary to Lassiter Swamp and the Chowan River in eastern Gates County, were designated the Duke Swamp study area (Fig. 1). Hoggard Mill Creek, tributary to

Table 1. Fishes collected in Duke Swamp and Hoggard Mill Creek, May 1972 through August 1972 (P = Present). Names from Bailey et al. (1970).

Species	Duke Swamp	Hoggard Mill Creek
Bowfin, *Amia calva*	P	P
American eel, *Anguilla rostrata*	P	P
Eastern mudminnow, *Umbra pygmaea*	P	P
Redfin pickerel, *Esox americanus americanus*	P	P
Chain pickerel, *Esox niger*	P	P
Golden shiner, *Notemigonus crysoleucas*	P	P
Ironcolor shiner, *Notropis chalybaeus*		P
Unidentified shiner, *Notropis* sp.	P	
Creek chubsucker, *Erimyzon oblongus*	P	P
Yellow bullhead, *Ictalurus natalis*	P	P
Brown bullhead, *Ictalurus nebulosus*	P	P
Tadpole madtom, *Noturus gyrinus*	P	P
Swampfish, *Chologaster cornuta*	P	P
Pirate perch, *Aphredoderus sayanus*	P	P
Lined topminnow, *Fundulus lineolatus*	P	
Mosquitofish, *Gambusia affinis*	P	
Mud sunfish, *Acantharchus pomotis*	P	P
Flier, *Centrarchus macropterus*	P	P
Banded pigmy sunfish, *Elassoma zonatum*		P
Black banded sunfish, *Enneacanthus chaetodon*	P	
Bluespotted sunfish, *Enneacanthus gloriosus*	P	P
Banded sunfish, *Enneacanthus obesus*	P	
Redbreast sunfish, *Lepomis auritus*		P
Pumpkinseed, *Lepomis gibbosus*	P	P
Warmouth, *Lepomis gulosus*	P	P
Bluegill, *Lepomis macrochirus*	P	P
Largemouth bass, *Micropterus salmoides*	P	P
Black crappie, *Pomoxis nigromaculatus*	P	P
Swamp darter, *Etheostoma fusiforme*	P	
Sawcheek darter, *Etheostoma serriferum*		P
Yellow perch, *Perca flavescens*		P
	26	25

the Cashie River near its confluence with the Roanoke River, is located in Bertie County. The Hoggard Mill Creek study area extended approximately 9.3 stream km downstream from the Bertie County SR 1301 bridge on Cucklemaker Swamp and the SR 1001 bridge on Flat Swamp (Fig. 1). The main stream channels of both streams were measured and divided into 0.4 kilometer study sections.

Both streams varied considerably in size within the study area. Main stream channels were generally 2 to 8 m wide and a few cm to 6 m deep.

Table 2. Population estimates of fishes collected from Duke Swamp, May through August 1972. N = number of each species per surface hectare; CL = 80% confidence limits; B = biomass in kg per surface hectare; %N = percent of total number; %B = percent of total biomass; * = data not available *or* < 0.1; and ∞ = infinite.

	Section 1				
Species	N	CL	B	%N	%B
Bowfin	22	(*-*)	8.3	.3	4.3
American eel	121	(62-∞)	1.7	1.8	.9
Eastern mudminnow	7	(5-∞)	.1	.1	.1
Redfin pickerel	1871	(1240-4549)	65.5	28.2	33.6
Chain pickerel	40	(*-*)	2.6	.6	1.3
Golden shiner	12	(*-*)	.1	.2	.1
Creek chubsucker	363	(255-1003)	13.1	5.5	6.7
Yellow bullhead	991	(541-18688)	35.6	14.9	18.2
Brown bullhead	99	(72-∞)	4.8	1.5	2.5
Tadpole madtom	0				
Pirate perch	1082	(640-2031)	6.5	16.3	3.3
Mud sunfish	109	(54-∞)	4.5	1.6	2.3
Flier	1174	(546-∞)	41.0	17.7	21.0
Blackbanded sunfish	136	(72-∞)	*	2.1	
Bluespotted sunfish	259	(126-∞)	1.6	3.9	.8
Banded sunfish	0				
Pumpkinseed	2	(*-*)	*	.0	
Warmouth	79	(42-∞)	7.1	1.2	3.6
Bluegill	217	(106-∞)	2.6	3.3	1.3
Largemouth bass	10	(*-*)	*	.2	
Black crappie	10	(*-*)	*	.2	
Swamp darter	2	(*-*)	*	.0	
Sawcheek darter	22	(12-∞)	*	.3	
TOTALS	6630		195.1		

The variation in volume of stream flow through a year had considerable influence on stream width due to the nearly uniform topography of the watersheds. Rises in stream level of approximately 1 m caused width increases of up to 0.8 km.

Population Estimates

Four study sections were randomly selected in each stream for fish population sampling. Sampling was conducted during summer low water periods using a combination of capture methods in an attempt to reduce bias from gear selectivity. Sections were blocked off with nets, and cylindrical poultry-wire traps, gill nets, a seine and a backpack Smith Root Type V electrofishing unit were used for collecting fish.

Table 2. (Continued)

Species	Section 5 N	CL	B	%N	%B
Bowfin	25	(*-*)	9.2	.1	1.0
American eel	546	(309-10381)	7.6	1.6	.8
Eastern mudminnow	1300	(813-4653)	11.7	3.9	1.2
Redfin pickerel	7050	(4653-17238)	246.6	20.9	25.8
Chain pickerel	0				
Golden shiner	670	(321-∞)	6.1	2.0	.6
Creek chubsucker	11764	(6217-224102)	423.2	34.9	44.2
Yellow bullhead	4700	(2150-∞)	169.0	13.9	17.7
Brown bullhead	502	(250-∞)	24.5	1.5	2.6
Tadpole madtom	0				
Pirate perch	5916	(4465-9449)	35.4	17.5	3.7
Mud sunfish	7	(*-*)	*	.0	
Flier	546	(358-3010)	19.1	1.6	2.0
Blackbanded sunfish	7	(*-*)	*	.0	
Bluespotted sunfish	242	(119-∞)	1.5	.7	.2
Banded sunfish	0				
Pumpkinseed	148	(91-∞)	*	.4	
Warmouth	0				
Bluegill	247	(141-∞)	2.9	.7	.3
Largemouth bass	7	(*-*)	*	.0	
Black crappie	0				
Swamp darter	0				
Sawcheek darter	57	(40-∞)	.1	.2	.0
TOTALS	33734		956.9		

The Petersen single census mark-recapture method (Ricker 1958) was used in estimating populations. Sampling was divided into a marking period and a censusing period. A week generally was required for sampling each study section and at least one night separated the two periods. During the marking period all fish captured in good condition and large enough to mark (generally > 75 mm) were fin clipped and released. Fish too small to mark were counted and this count was considered a minimal population estimate. All fish (of the size marked) captured during censusing were inspected for marks. The same sampling effort was employed during the marking period and the censusing period.

An indication of fish biomass was obtained from the product of the numerical population estimates and the mean weight of a sample of fish (by species) collected from the study streams using the same collection techniques (Tarplee 1975). In cases where the number of individuals considered in obtaining the mean weight was small, data from 1973 rotenone samples (Pardue et al. 1975) were also used.

Table 2. (Continued)

	Section 6				
Species	N	CL	B	%N	%B
Bowfin	12	(*-*)	4.6	.1	1.6
American eel	82	(40-∞)	1.1	.8	.4
Eastern mudminnow	929	(425-∞)	8.3	8.9	2.6
Redfin pickerel	3039	(2078-6133)	106.3	29.3	36.5
Chain pickerel	27	(12-∞)	1.8	.3	.6
Golden shiner	237	(111-∞)	1.2	2.3	.4
Creek chubsucker	1391	(1048-1969)	50.0	13.4	17.2
Yellow bullhead	726	(484-2046)	26.1	7.0	9.0
Brown bullhead	178	(109-3403)	8.7	1.7	3.0
Tadpole madtom	2		*	.0	
Pirate perch	1285	(786-4623)	7.7	12.4	2.6
Mud sunfish	35	(20-∞)	1.5	.3	.5
Flier	1920	(1018-36934)	67.1	18.5	23.1
Blackbanded sunfish	0				
Bluespotted sunfish	131	(64-∞)	.8	1.3	.3
Banded sunfish	0				
Pumpkinseed	54	(30-∞)	*	.5	
Warmouth	25	(15-∞)	2.2	.2	.8
Bluegill	304	(163-∞)	3.7	2.9	1.3
Largemouth bass	0				
Black crappie	0				
Swamp darter	0				
Sawcheek darter	12	(*-*)	*	.1	
TOTALS	10389		291.1		

RESULTS AND DISCUSSION

The 27 species of fish collected from Duke Swamp and 24 species collected from Hoggard Mill Creek were typical of lowland blackwater streams (Table 1). Differences in the species lists can be largely attributed to those smaller species less susceptible to capture, and those represented by low numbers of individuals which may actually occur in both streams. Several additional species were reported from these areas by Pardue et al. (1975).

Population estimates of markable-size fish in the sampled sections of Duke Swamp and Hoggard Mill Creek are presented on a per hectare basis in Table 2 and 3. The area of water considered was only that contained within the main stream channel and did not reflect increases in surface area which occurred when water levels rose above the main channel banks.

The Petersen method is a single census technique, so confidence limits

Table 2. (Continued)

	Section 34				
Species	N	CL	B	%N	%B
Bowfin	74	(54-∞)	27.6	.4	5.0
American eel	334	(208-∞)	4.7	1.7	.9
Eastern mudminnow	801	(408-∞)	7.2	4.0	1.3
Redfin pickerel	5960	(5083-7440)	208.5	29.6	38.1
Chain pickerel	0				
Golden shiner	667	(566-927)	6.1	3.3	1.1
Creek chubsucker	79	(59-420)	2.8	.4	.5
Yellow bullhead	3121	(1433-∞)	112.2	15.5	20.5
Brown bullhead	1586	(882-30500)	77.7	7.9	14.2
Tadpole madtom	0				
Pirate perch	4159	(3425-5513)	24.9	20.6	4.5
Mud sunfish	35	(*-*)	1.5	.2	.3
Flier	1952	(1762-2271)	68.3	9.7	12.5
Blackbanded sunfish	0				
Bluespotted sunfish	326	(158-∞)	1.9	1.6	.3
Banded sunfish	1001	(549-18898)	*	5.0	
Pumpkinseed	17	(*-*)	*	.1	
Warmouth	49	(37-∞)	4.4	.2	.8
Bluegill	0				
Largemouth bass	0				
Black crappie	0				
Swamp darter	0				
Sawcheek darter	0				
TOTALS	20161		547.8		

were estimated by considering R (recaptures) as a binomial and using tables of confidence limits of binomial proportions (Mainland et al. 1956). The 80 percent level of confidence was selected for use in examining these estimates, as variability is often high in field studies of fish and wildlife populations and an 80 percent confidence level is often adequate for ecological evaluation and management.

There was considerable variation in numbers of fish between the sampled sections of Duke Swamp, with estimates ranging from 6630 fish weighing 195.1 kg per surface hectare to 33,734 fish weighing 956.9 kg (Table 2). Redfin pickerel, Yellow bullhead, Pirate perch and American eel, the most abundant fishes collected (pooled estimates), made up 69.0 percent of the estimated total. Large differences existed among species in the variation in population estimates between study sections. For example, Creek chubsucker estimates varied considerably between sections while Redfin pickerel were abundant in all sections.

Table 2. (Continued)

Species	Totals (Based on Pooled Data) N	CL	B	%N	%B
Bowfin	17	(*-*)	6.2	.1	1.8
American eel	1433	(326-11937)	20.1	11.3	5.9
Eastern mudminnow	1065	(494-2911)	9.6	8.4	2.8
Redfin pickerel	2933	(2671-3487)	102.7	23.0	30.4
Chain pickerel	133	(40-1334)	8.5	1.0	2.5
Golden shiner	185	(143-250)	1.7	1.5	.5
Creek chubsucker	381	(346-423)	13.7	3.0	4.1
Yellow bullhead	2310	(1574-5866)	83.2	18.1	24.6
Brown bullhead	1035	(376-3571)	50.7	8.1	15.0
Tadpole madtom	2	(*-*)	.0	.0	.0
Pirate perch	2110	(1762-2553)	12.7	16.6	3.8
Mud sunfish	168	(43-1542)	6.9	1.3	2.0
Flier	554	(484-640)	19.4	4.4	5.7
Blackbanded sunfish	15	(*-*)	*	.1	
Bluespotted sunfish	49	(*-*)	.3	.4	.1
Banded sunfish	232	(59-2009)	*	1.8	
Pumpkinseed	17	(*-*)	*	.1	
Warmouth	20	(*-*)	1.7	.2	.5
Bluegill	49	(*-*)	.6	.4	.2
Largemouth bass	5	(*-*)	*	.0	
Black crappie	2	(*-*)	*	.0	
Swamp darter	2	(*-*)	*	.0	
Sawcheek darter	12	(*-*)	.0	.1	
TOTALS	12729		338.0		

Pirate perch, American eel, Yellow bullhead and Redfin pickerel were the most numerous species in Hoggard Mill Creek, making up 79.2 percent (pooled estimate) of the total (Table 3). Total estimates ranged from 17,656 to 103,891 fish per surface hectare and biomass estimates ranged from 218.8 kg to 1606.9 kg per surface hectare among the four sections sampled. The Pirate perch was the only species abundant in all sections. As in Duke Swamp there was considerable variation in the number of individuals of several species between study sections. Section 2, the section with the greatest fish density, primarily contained juvenile American eels, while Section 21 had a density of only 74 eels per surface hectare.

In Duke Swamp 70 percent of the estimated total fish biomass was made up of Redfin pickerel, Yellow bullhead and Brown bullhead. Most of the additional 30 percent was composed of American eel, Flier, Pirate Perch and Creek chubsucker. Six species—Yellow bullhead, Redfin pickerel, American eel, Pirate perch, Flier and Mud sunfish—composed

Table 3. Population estimates of fishes collected from Hoggard Mill Creek, May through August 1972. N = number of each species per surface hectare; CL = 80% confidence limits; B = biomass in kg per surface hectare; %N = percent of total number; %B = percent of total biomass; * = data not available *or* < 0.1; and ∞ = infinite.

	Section 19				
Species	N	CL	B	%N	%B
Bowfin	10	(7-∞)	3.7	.0	1.7
American eel	2780	(1619-15590)	38.9	13.2	17.8
Eastern mudminnow	22	(10-∞)	.2	.1	.1
Redfin pickerel	526	(314-2936)	18.4	2.5	8.4
Chain pickerel	2	(*-*)	.1	.0	.0
Golden shiner	32	(20-∞)	.2	.2	.1
Creek chubsucker	190	(131-670)	6.8	.9	3.1
Yellow bullhead	818	(430-15750)	29.4	3.9	13.4
Brown bullhead	2	(*-*)	.0	.0	.0
Tadpole madtom	1426	(660-∞)	7.2	6.8	3.3
Pirate perch	12792	(9953-19217)	76.6	60.7	35.0
Mud sunfish	314	(151-∞)	12.9	1.5	5.9
Flier	128	(67-∞)	4.5	.6	2.1
Bluespotted sunfish	944	(442-∞)	5.6	4.5	2.6
Redbreast sunfish	2	(*-*)	*	.0	
Pumpkinseed	7	(*-*)	*	.0	
Warmouth	146	(106-∞)	13.0	.7	5.9
Bluegill	5	(*-*)	.1	.0	.0
Black crappie	5	(*-*)	*	.0	
Sawcheek darter	934	(423-∞)	1.2	4.4	.5
Yellow perch	0		.0	.0	.0
TOTALS	21083		218.8		

92 percent of the estimated fish biomass in Hoggard Mill Creek. This comparison indicates that most of the biomass in both these streams is made up of species desired by fisherman.

The great variation in population estimates among the sections and between the streams sampled is probably primarily due to habitat difference. Some variation, however, may be due to changes in sampling gear efficiency in different stream types. The larger numbers of Pirate perch and American eel in Hoggard Mill creek may be related to the greater amount of aquatic vegetation in that stream. Section 2 of Hoggard Mill Creek contained dense beds of aquatic vegetation and a soft, muddy substrate. Densities of juvenile American eel and Pirate perch were much greater there than in any other sampling area in either stream.

In the larger sections of streams studied (Section 1 in Duke Swamp and part of Section 19 in Hoggard Mill Creek) some of the sampling gear, such

Table 3. (Continued)

	Section 8				
Species	N	CL	B	%N	%B
Bowfin	0		.0	.0	.0
American eel	1836	(1181-6541)	25.2	5.8	3.8
Eastern mudminnow	996	(492-∞)	9.0	3.2	1.4
Redfin pickerel	7144	(6061-9343)	249.9	22.6	37.6
Chain pickerel	5	(*-*)	.3	.0	.0
Golden shiner	133	(*-*)	1.0	.4	.2
Creek chubsucker	363	(232-2009)	13.1	1.2	2.0
Yellow bullhead	4223	(2644-15068)	126.9	13.4	19.1
Brown bullhead	0		.0	.0	.0
Tadpole madtom	1166	(549-∞)	5.8	3.7	.9
Pirate perch	9298	(7309-14435)	55.7	29.5	8.4
Mud sunfish	1866	(1223-5256)	78.9	5.9	11.9
Flier	2291	(1554-5542)	79.8	7.3	12.0
Bluespotted sunfish	2098	(951-∞)	12.6	6.7	1.9
Redbreast sunfish	5	(*-*)	*	.0	
Pumpkinseed	0			.0	
Warmouth	57	(*-*)	5.0	.2	.8
Bluegill	0		.0	.0	.0
Black crappie	0			.0	
Sawcheek darter	44	(27-∞)	.1	.1	.0
Yellow perch	22	(*-*)	.9	.1	.1
TOTALS	31547		664.2		

as the backpack electrofishing unit, became less effective and resulted in capture of fewer individuals and wider confidence limits.

This variation in fish population with habitat distribution appears to be a characteristic of these swamp systems. In this study we attempted to estimate the fish populations in the study area by using randomly chosen, relatively large sampling areas. The results provide a list of species found in these swamp streams, estimates of their abundance, and, perhaps most important, an indication of the variation found among areas within streams as well as between streams.

The number of fish collected that were too small to mark includes both species with a small adult size and juvenile fishes. These fish are included in the area species list (Table 1) and their numbers were reported by Tarplee (1975). Largest differences occurring between the two streams were in Swampfish and Ironcolor shiner, which were much more abundant in Hoggard Mill Creek than in Duke Swamp.

The estimates of fish biomass in both creeks are slightly higher than

Table 3. (Continued)

	Section 2				
Species	N	CL	B	%N	%B
Bowfin			.0		
American eel	37265	(23754-106347)	35.9	32.4	
Eastern mudminnow	18453	(8209-∞)	165.8	17.8	10.3
Redfin pickerel	11080	(6578-62012)	387.5	10.7	24.1
Chain pickerel	0		.0	.0	.0
Golden shiner	30	(17-∞)	.2	.0	
Creek chubsucker	0			.0	
Yellow bullhead	3877	(2323-21663)	139.1	3.7	8.7
Brown bullhead	0		.0	.0	.0
Tadpole madtom	173	(109-3274)	.9	.2	.1
Pirate perch	23951	(17880-37189)	143.5	23.1	8.9
Mud sunfish	536	(324-10232)	22.0	.5	1.4
Flier	2192	(1171-41752)	188.8	2.1	11.7
Bluespotted sunfish	6304	(2891-∞)	37.8	6.1	2.4
Redbreast sunfish	0			.0	
Pumpkinseed	0			.0	
Warmouth	0		.0	.0	.0
Bluegill	0		.0	.0	.0
Black crappie	0			.0	
Sawcheek darter	30	(17-∞)	.0	.0	.0
Yellow perch	0			.0	
TOTALS	103891		1606.9		

values reported for Louisiana backwater areas and rivers by Lantz (1970a, b), and within the range of values reported for the same Louisiana backwater area by Lambou (1959). These biomass estimates are also slightly higher on the average than fish populations reported from North Carolina swamp streams by Bayless and Smith (1963) and Tarplee et al. (1971), although most values in this study were within the range reported in the literature.

ACKNOWLEDGMENTS. — This work was supported by the N. C. Wildlife Resources Commission, the Water Resources Research Institute of the University of North Carolina, U. S. Division of Ecological Services, and the N. C. Cooperative Fishery Unit. Dr. Melvin T. Huish provided guidance and assistance in all phases of the study. This paper is from a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at North Carolina State University.

Table 3. (Continued)

Species	Section 21 N	CL	B	%N	%B
Bowfin	0				
American eel	74	(44-∞)	1.0	.4	.3
Eastern mudminnow	3902	(3158-5389)	35.1	22.1	10.8
Redfin pickerel	5864	(4979-7386)	205.1	33.2	63.1
Chain pickerel	0		.0	.0	.0
Golden shiner	57	(*-*)	.4	.3	.1
Creek chubsucker	30	(*-*)	1.1	.2	.3
Yellow bullhead	1035	(591-∞)	37.2	5.9	11.4
Brown bullhead	0		.0	.0	.0
Tadpole madtom	0		.0	.0	.0
Pirate perch	6370	(4675-8634)	38.1	36.1	11.7
Mud sunfish	74	(59-1404)	3.0	.4	.9
Flier	74	(40-∞)	2.6	.4	.8
Bluespotted sunfish	166	(119-∞)	1.0	.9	.3
Redbreast sunfish	0			.0	
Pumpkinseed	0			.0	
Warmouth	5	(*-*)	.4	.0	.1
Bluegill	0			.0	.0
Black crappie	0			.0	
Sawcheek darter	5	(*-*)	.0	.0	.0
Yellow perch	0			.0	.0
TOTALS	17656		325.0		

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Table 3. (Continued)

Species	Totals (Based on Pooled Data)				
	N	CL	B	%N	%B
Bowfin	2	(*-*)	1.3	.0	.2
American eel	8569	(5409-13838)	120.0	23.5	19.5
Eastern mudminnow	1940	(1483-2607)	17.5	5.3	2.8
Redfin pickerel	3973	(3482-4571)	139.1	10.9	22.6
Chain pickerel	2	(*-*)	.1	.0	.0
Golden shiner	133	(59-492)	1.2	.4	.2
Creek chubsucker	222	(136-408)	8.0	.6	1.3
Yellow bullhead	4265	(2340-761)	153.5	11.7	24.9
Brown bullhead	2	(*-*)	.1	.0	.0
Tadpole madtom	2797	(623-2238)	14.0	7.7	2.3
Pirate perch	12071	(10316-14201)	72.4	33.1	11.8
Mud sunfish	907	(521-1658)	37.1	2.5	6.0
Flier	1332	(825-2656)	46.6	3.6	7.6
Bluespotted sunfish	173	(*-*)	1.0	.5	.2
Redbreast sunfish	2	(*-*)	*	.0	
Pumpkinseed	5	(2-44)	*	.0	
Warmouth	47	(32-89)	4.1	.1	.7
Bluegill	2	(*-*)	.0	.0	.0
Black crappie	2	(*-*)	*	.0	
Sawcheek darter	59	(*-*)	.1	.2	.0
Yellow perch	2	(*-*)	.1	.1	.0
TOTALS	36507		616.1		

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Accepted 9 January 1979

Some Snake Food Records from the Carolinas

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ABSTRACT. — Some 690 food items were recovered from digestive tracts of 479 snakes of 32 species from North and South Carolina. The most extensive series were from the colubrids *Regina septemvittata*, which contained only crayfish; *Virginia striatula*, which fed exclusively on earthworms; *Coluber constrictor*, whose diet was varied; *Opheodrys aestivus*, which contained mostly lepidoptera larvae, plus orthoptera and arachnids; *Elaphe obsoleta*, which consumed small mammals, young birds, and birds' eggs; and the crotalid, *Agkistrodon contortrix*, which contained mostly small mammals and lepidoptera larvae. Comments made by other authors anent secondary ingestion and lengthy retention of indigestible residues are questioned.

INTRODUCTION

Studies of the food habits of snakes from the Carolinas, or closely adjacent areas, include those of Uhler et al. (1939), Hamilton and Pollack (1955, 1956), Savage (1967), and Garton and Dimmick (1969). Similar studies in other areas are those of Raney and Roecker (1947), Allen and Swindell (1948), Clark (1949), Carpenter (1952), Barbour (1956), Brown (1958), Klimstra (1959a,b), Bush (1959), Fitch (1960, 1963a,b), Burkett (1966) and Wharton (1969). Wright and Bishop (1915) included some food notes in their Okefenokee work.

This paper provides information on 690 food items from 479 snakes of 32 species, all from North and South Carolina. For better or worse, all common and scientific names used here for reptiles and amphibians are those provided in Collins et al. (1978).

MATERIALS AND METHODS

A great many of the snakes were road-kills, but many also were secured alive. The presence of food in live specimens could usually be detected by palpation, and it could then be removed by manual manipulation. Dead specimens required dissection. Specimens with empty stomachs are not reported. Emphasis has purposely been placed upon the taking of certain food items rather than upon the volume of such items, especially when many small items of relatively similar size were involved.

RESULTS

Nerodia erythrogaster erythrogaster, Redbelly Water Snake.

Five stomachs of this species contained 12 food items: 10 amphibians (6 undetermined tadpoles, 4 *Bufo terrestris*); and 2 fish (a *Micropterus salmoides* and a "sunfish").

Snakes involved were from Columbus Co., NC, and Horry and Sumter cos., SC.

Nerodia sipedon sipedon, Northern Water Snake.

Specimens were mostly from a number of sandy-bottomed, channelized streams of the North Carolina Piedmont and several mountain streams in the northwestern corner of the state. Food habits in lacustrine habitats might differ.

Forty-five items were recorded from 30 stomachs: 17 anurans (6 *Bufo w. fowleri*, 3 *Hyla chrysoscelis*, 3 *Scaphiopus holbrooki*, 2 *Rana catesbeiana*, 1 *Hyla crucifer*, 1 *Rana spenocephala*, and 1 undetermined); 17 salamanders (5 undetermined larvae, 4 *Desmognathus fuscus*, 2 larvae of *Pseudotriton* sp., 1 *Eurycea bislineata wilderae*, 1 *Plethodon glutinosus*, 4 undetermined); and 11 fish (5 *Semotilus atromaculatus*, 1 *Etheostoma* sp., 1 *Ictalurus* sp., 1 *Hypentelium nigricans*, 1 "sunfish," 2 undetermined).

I was surprised at the prominence of amphibians (75.6 percent of all items), and initially felt that this might correlate with the limited fish life in the channelized streams. However, 15 of the 19 food items from the unchannelized mountain streams were amphibians. Two of the larger snakes had eaten *Rana catesbeiana* with displacement volumes of 110 and 135 ml. Three of the largest meals taken represented 26, 40 and 56 percent of the weight of the respective snakes.

Specimens were from Alleghany, Ashe, Cabarrus, Caldwell, Lincoln, Mecklenburg, and Watauga cos., NC.

Nerodia fasciata fasciata, Banded Water Snake.

Twelve stomachs of this Coastal Plain form contained 20 food items: 12 frogs and toads (6 *Bufo terrestris*, 3 *Hyla gratiosa*, 1 *Hyla chrysoscelis*, 2 undetermined); 4 salamanders (2 *Desmognathus auriculatus*, 1 *Necturus punctatus*, 1 undetermined); and 4 fish (3 *Fundulus* sp., 1 undetermined). This species has been observed eating dead anurans on the highway on a rainy June night in Brunswick County, North Carolina.

Snakes examined were from Brunswick, Carteret, Craven and Columbus cos., NC, and Chesterfield and Sumter cos., SC.

Regina septemvittata, Queen Snake.

Raney and Roecker (1947), reporting on 45 stomachs from Erie County, New York, found crayfish in 44 and a dragonfly nymph in each

of 2. Wood (1949) reported the contents of 6 Ohio stomachs and 43 disgorgings as all crayfish, except for a single catfish. He further proposed that crayfish, either dead or alive, are probably taken in the soft-shelled condition following molting. My material supports these observations. Thirty-two stomachs contained remains of 35 crayfish, and fecal samples from 31 additional snakes contained gastroliths from 49 crayfish. The crayfish found in many stomachs appeared to have been soft-shelled, but, in a few instances, I could not be certain of this. The fecal gastroliths presumably were from crayfish at, or extremely close to, the molting state.

The majority of crayfish were small to medium in size, but several were relatively large. One first-year snake had eaten a very small crayfish, 20 mm total length (TL). However, a 32 cm TL snake, probably in its second year, contained a crayfish of 50 mm TL. No more than two crayfish were found in any stomach. Three of 31 fecal samples contained gastroliths from three crayfish. Of 24 crayfish whose orientation was noted, 15 had been swallowed head-first, 9 tail-first.

Specimens were from Alexander, Alleghany, Ashe, Buncombe, Catawba, Guilford, Iredell, Mecklenburg, Transylvania, Watauga and Wilkes cos., NC.

Seminatrix pygaea paludis, Carolina Swamp Snake.

Only four specimens, all from Brunswick County, North Carolina, contained food. Two had earthworm remains; a third had a very small fish (not over 20 mm TL), partly digested and unidentified; and the fourth contained fragments of a small, unidentified arthropod.

Storeria dekayi, Brown Snake.

Eight stomachs, from Columbus, Mecklenburg and Rowan counties, North Carolina, contained 5 earthworms and 4 small slugs.

Storeria occipitomaculata occipitomaculata, Northern Redbelly Snake.

Two stomachs, from Cabarrus and Columbus counties, North Carolina, yielded three very small (0.1 ml volume) slugs.

Thamnophis sirtalis sirtalis, Eastern Garter Snake.

Fourteen stomachs contained 16 food items: 8 salamanders (including *Pseudotriton* sp., *Plethodon glutinosus*, *Ambystoma opacum*, *Eurcyea bislineata*, 3 undetermined); 6 anurans (1 *Bufo quercicus*, 1 *Bufo w. fowleri*, 1 *Hyla chrysocelis*, 1 *Rana palustris*, 2 undetermined); and 2 earthworms (found in 2 of 5 snakes from the mountains). One snake was observed eating small, dead frogs on a highway in Brunswick County, North Carolina, on a rainy June night.

Snakes examined were from Brunswick, Columbus, Davidson, Jackson, Mecklenburg and Watauga cos., NC, and Hampton Co., SC.

Thamnophis sauritus sauritus, Eastern Ribbon Snake.

Thirteen stomachs yielded 14 relatively small amphibians: 11 anurans (3 *Acris gryllus*, 2 *Pseudacris triseriata feriarum*, 1 *Pseudacris brimleyi*, 2 *Hyla femoralis*, 1 *Hyla* sp., 1 just-metamorphosed *Rana catesbeiana*, 1 *Bufo* sp.); and 3 salamanders (2 *Desmognathus fuscus*, 1 *Eurycea bislineata*).

Snakes examined were from Ashe, Brunswick, Cabarrus, Jones and Mecklenburg cos., NC and Colleton and Lee cos., SC.

Virginia striatula, Rough Earth Snake.

Forty specimens contained only remains of earthworms. In 15 of these specimens the evidence consisted of dark, earthy material, plus setae in the intestine.

Snakes were from Brunswick, Columbus, Duplin, Guilford, Mecklenburg and Rowan cos., NC.

Virginia valeriae valeriae, Eastern Earth Snake.

Two of seven specimens examined contained only earthworm remains. The snakes were from Mecklenburg Co., NC, and Kershaw Co., SC.

Heterodon platyrhinos, Eastern Hognose Snake.

Toads were the only food I found in this snake. Five stomachs, all from Mecklenburg County, North Carolina, contained 6 *Bufo woodhousei fowleri*. One snake, 40 cm TL and weighing 26 gm, had just swallowed a toad weighing 29 gm, a truly gigantic meal.

Diadophis punctatus, Ringneck Snake.

These snakes feed largely upon small, slender-bodied prey, difficult to detect by palpation. Twelve stomachs contained 12 food items: 9 salamanders (3 *Plethodon jordani "metcalfi"*, 1 *P. cinereus*, 1 *P. glutinosus*, 1 *Eurycea quadridigitata*, 3 undetermined); and 3 earthworms. All stomachs (8) from the mountain region contained salamanders; the earthworms were in 3 of 4 Coastal Plain snakes. One mountain specimen contained a small lepidoptera larva (phalaenid = "noctuid") along with a salamander. The salamander might have disgorged the insect larva, but I could not be certain of this.

Specimens were from Alexander, Avery, Caldwell, Columbus, Duplin, Macon, and Watauga cos., NC, and Dorchester Co., SC.

Carphophis amoenus amoenus, Eastern Worm Snake.

Seven stomachs yielded only earthworms; 16 others had dark, earthy material and earthworm setae in the intestines.

Snakes examined were from Caldwell, Columbus, Duplin, Mecklenburg and Stanly cos., NC.

Farancia erytrogramma ertyrogramma, Rainbow Snake.

In late April in Sumter County, South Carolina, a snake (86 cm TL) was found at night laboriously attempting to swallow a mammoth tadpole of *Rana heckscheri* which it had dragged some 3 m up the bank of a pond.

Coluber constrictor constrictor, Northern Black Racer.

The food of this snake is quite diverse. A series of 86 items from 53 stomachs included reptiles, mammals, amphibians, arthropods, birds and a small snail, in that order of frequency and apparently all taken independently. There was great variation in size of animal taken, from a fairly large vole or snake to a small lepidoptera larva or lycosid spider. Reptiles and mammals ranked almost equally in bulk and, with amphibians, comprised 80 percent of the food items and 95.4 percent of volume. The 38 reptiles included: 22 lizards (9 *Scincella lateralis*, 5 *Eumeces* sp., 2 *Ophisaurus* sp., 2 *Anolis carolinensis*, 1 *Sceloporus undulatus*, 1 *Cnemidophorus sexlineatus*, 2 undetermined); 15 snakes (5 *Carphophis amoenus*, 3 *Opheodrys aestivus*, 2 *Nerodia fasciata*, 1 *Coluber constrictor*, 1 *Tantilla coronata*, 1 *Virginia striatula*, 1 undetermined, and a fragment of shed skin); and 1 young *Kinosternon subrubrum*. The 15 mammals included: 3 *Microtus pinetorum* (adult and young), 1 *Microtus pennsylvanicus* (young), 4 *Peromyscus leucopus* (mostly young), 1 *Sigmodon hispidus*, 1 *Mus musculus* and 5 undetermined. The 16 amphibians included: 6 *Acris gryllus*, 1 *Rana sphenocephala*, 1 *Rana virgatipes*, 2 just-metamorphosed *Rana catesbeiana*, 2 *Hyla chrysoscelis*, 2 undetermined frogs and 2 *Desmognathus fuscus*. While arthropods made up 15 percent of the items, their bulk was very limited (1.3 percent of volume). They included 7 lepidoptera larvae, 3 lycosid spiders, 2 moths and 1 diptera larva. Remains of a small, unidentified bird occured in each of three stomachs (2.9 percent of volume). At least two of these were nestlings.

Sixty-four percent of the stomachs contained a single food item, but one contained seven small frogs (mostly *Acris*), another had two young mice and two *Desmognathus fuscus*, and a third, collected on an April morning, had three very fresh *Carphophis amoenus*. On a morning in early May, a 110 cm TL male racer was found vigorously swallowing a 50 cm TL male of its own species. The hatchling eastern mud turtle found in a September specimen was still alive, and had been in the snake's stomach for at least two hours.

Snakes examined were from Brunswick, Cabarrus, Chatham, Columbus, Guilford, Iredell, Lincoln, Mecklenburg, Montgomery, Moore,

Richmond, Rowan, Rutherford and Watauga cos., NC, and Abbeville, Barnwell, Berkeley, Charleston, Dorchester, Horry, Kershaw, Lancaster, Marlboro and Sumter cos., SC.

Masticophis flagellum flagellum. Eastern Coachwhip.

Sixteen food items were recovered from 12 stomachs: 8 reptiles (6 *Cnemidophorus sexlineatus*, 1 *Eumeces* sp., 1 35 mm CL *Chrysemys concinna*); 5 mammals (1 *Peromyscus* sp. 4 undetermined); and 3 arthropods (2 cicada nymphs and 1 large *Amblyomma tuberculatum*, a tick). Both cicada nymphs were in a small snake from Charleston County, South Carolina. The tick, in the stomach of a larger snake, was 27 mm long and engorged with blood. Cooney and Hays (1972) regard this tick as host specific in the adult and nymphal stages to the tortoise, *Gopherus polyphemus*, and they believe it to be the largest tick in the United States, possibly the largest known. (A number of non-engorged ticks were collected from a large tortoise that was intercepted nearby.) The snake involved was found in a shallow Gopher tortoise burrow in Jasper County, South Carolina, along with specimens of *Bufo terrestris*. However, neither this snake nor another found in a similar situation had taken a toad.

Snakes examined were from Cumberland and Hoke cos., NC, and Charleston, Chester, Chesterfield, Edgefield, Jasper, Kershaw, Lexington, McCormick and Sumter cos., SC.

Opheodrys aestivus, Rough Green Snake.

This snake is partial to insect and arachnid prey. Fifty-nine stomachs contained 125 food items, mostly of three major groupings: lepidoptera (59.2 percent of items: 2 moths, 72 larvae); orthoptera (17.6 percent of items: 15 grasshoppers, 4 field and tree crickets, 2 mantids, 1 undetermined); and arachnids (13.6 percent of items: 12 spiders, 1 spider egg cocoon, 4 phalangids). One tiger beetle, 5 undetermined insects and 4 small snails were also present. Lepidoptera occurred almost twice as frequently as both the other major groups combined and larvae of phalaenids, hesperiids, goemetrids, nymphalids and sphingids were recognized. One was only 10 mm in length. Recognizable spiders included lycosids, araneids and attids. Stomachs contained from one to eight food items.

These snakes were collected from April to October, with 59 percent taken during June, July and August. They were from Alexander, Brunswick, Chatham, Columbus, Craven, Guilford, Iredell, Mecklenburg, Richmond and Rowan cos., NC, and Berkeley, Colleton, Dillon, Horry and Sumter cos., SC.

Elaphe guttata guttata, Corn Snake

Ten food-laden specimens of this largely Coastal Plain form were encountered. They yielded 10 food items: 9 mammals (3 *Microtus*

pennsylvanicus, 2 *Peromyscus* sp., 1 *Oryzomys palustris*, 3 undetermined remains); and 1 unidentified bird.

Snakes examined were from Brunswick and Columbus cos., NC, and Colleton, Dorchester, Horry and Sumter cos., SC.

Elaphe obsoleta obsoleta, Black Rat Snake.

Thirty-nine stomachs yielded 51 food items, including four sets of eggs counted as single items. This snake appears to feed mainly on small mammals and young birds. Mammals comprised 59 percent of the food items (64 percent of volume) in this sample, and birds 37 percent of the items (34 percent of volume). Half of the 30 mammals were *Microtus* sp. (9) and *Peromyscus* sp. (6). Others were: 2 young *Rattus norvegicus* (one of 27 cm TL, the other smaller), 2 *Tamias striatus*, 2 *Condylura cristata*, 2 *Sigmodon hispidus*, 1 *Mus musculus*, 1 *Glaucomys volans*, 1 *Blarina brevicauda carolinensis*, 1 *Sciurus carolinensis* (tail only), 1 young *Sylvilagus floridanus* and 2 undetermined.

One snake contained remains of two hen eggs, another had two Carolina Wren eggs, and one from the mountains had swallowed ten Ruffed Grouse eggs. Recognizable young birds from other snakes included: American Robin, Cardinal, Yellow-breasted Chat, three Blue Jays and a hatchling Bobwhite. In nine other cases bird remains found were not identifiable.

One specimen had eaten a group of six adherent snake eggs, whose size, shape, number and other features suggested the possibility of *Lampropeltis getulus*. A first-year snake weighing 12 gm contained a *Scelopours undulatus*.

Six snakes had taken unusually large meals that ranged from 24 to 46 percent (average 36 percent) of the weight of the snake.

Snakes examined were from Anson, Ashe, Burke, Cabarrus, Caldwell, Iredell, McDowell, Mecklenburg, Montgomery, Stanly, Stokes, Watauga and Wilkes cos. NC, and Aiken Co., SC.

Elaphe obsoleta quadrivittata, Yellow Rat Snake.

Food was found in two specimens from Berkeley and Horry counties, South Carolina: a young rabbit weighing 140 gm; and fragments of several pale blue eggs, possibly those of an Eastern Bluebird.

Pituophis melanoleucus melanoleucus, Northern Pine Snake.

A single, medium-sized specimen, road-killed in late June in Richmond County, North Carolina, contained four Bobwhite eggs.

Lampropeltis getulus getulus, Eastern Kingsnake.

Eight stomachs yielded eight food items: 5 reptiles (1 *Ophisaurus attenuatus*, 2 *Opheodrys aestivus*, 1 *Diadophis punctatus*, 1 large *Lampropeltis*

calligaster rhombomaculata); 2 turtle eggs, from two specimens collected in late May and mid-June; and a decaying post-nestling Mockingbird known to have been eaten as carrion.

Snakes examined were from Carteret, Columbus, Mecklenburg and Surry cos., NC, and Colleton, Orangeburg and Williamsburg cos., SC.

Lampropeltis triangulum elapsoides, Scarlet Kingsnake.

Two snakes, from Berkeley and Sumter counties, South Carolina, contained three specimens of the lizard, *Scincella lateralis*.

Lampropeltis calligaster rhombomaculata, Mole Kingsnake.

Six stomachs yielded 12 food items: 11 small mammals (1 adult *Microtus pinetorum*, 10 young *Microtus pennsylvanicus*, 1 undetermined); and 1 snake (*Opheodrys aestivus*). One snake had taken three young meadow voles which, from their sizes, were clearly from two different litters. The largest meal, five young meadow voles, had been taken by an egg-laden female snake in early May.

Snakes were from Mecklenburg and Rowan cos., NC, and Spartanburg Co., SC.

Cemophora coccinea copei, Northern Scarlet Snake.

Some early literature statements regarding food of *Cemophora* are rather vague. Dickson (1948) first noted this snake's feeding on reptile eggs, and contributions by Neill (1951), Minton and Bechtel (1958) and Palmer and Tregembo (1970) also focused on this topic.

Most *Cemophora* that I examined did not contain food. A specimen from Moore County, North Carolina, taken in late July, contained remains of three small snake eggs (possibly *Diadophis*). An individual from Brunswick County, collected in late May, had swallowed two small eggs, apparently of a snake. A specimen collected in mid-June in Sumter County, South Carolina, contained a collapsed egg "shell" 8 mm long, evidently of *Scincella lateralis*. It was far down in the intestine and apparently was going to pass through the gut undigested. This snake has been cornered in a sunken cistern and partly swallowed, tail first, by a large *Bufo terrestris*. The intestines of several snakes contained one or more small masses of sandy or earthy material, but these masses did not include earthworm setae. The stomachs of one or two of my early snakes contained pale, yellow, fluid material. When I later saw Dickson's (1948) note, I realized this might have been ingested egg material.

Tantilla coronata, Southeastern Crowned Snake.

Five snakes contained remains of five small centipedes and two small beetle larvae of cucujoid type.

Snakes examined were from Alexander and Cabarrus cos., NC, and Richland Co., SC.

Micrurus fulvius fulvius, Eastern Coral Snake.

The intestine of a single specimen for Aiken County, South Carolina, contained smooth scales of a snake.

Agkistrodon contortrix, Copperhead.

A series of 35 stomachs yielded 62 items, chiefly small mammals and larvae of lepidoptera. Mammal remains ranked first in volume (59.2 percent) but second as percentage of total food items (37.1). Among the remains of 23 mammals, those identifiable were: 5 *Peromyscus* sp., 4 *Microtus pennsylvanicus*, 1 *Microtus pinetorum*, 1 *Zapus hudsonius*, 1 *Reithrodontomys humulis* and 1 *Blarina brevicauda carolinensis*. Insects ranked second in volume (24.9 percent) and first in percentage of food items (56.5). They included 33 larvae of lepidoptera, 1 cicada nymph and 1 adult dragonfly. The relative prominence of these larvae is due partly to one large copperhead's having taken 20 specimens of *Anisota senatoria* (Citheroniidae). This caterpillar occurred also in four other stomachs. Another snake had eaten two large saturniid moth larvae. Eight of the nine specimens that contained larvae were collected in September or October. The presence of a fresh adult dragonfly in one stomach was surprising. In the caudal end of the same stomach was mouse-colored fur of some small mammal that apparently had been eaten much earlier. James D. Brown has given me verbal permission to report that each of three snakes whose remains he examined in northern Craven County, North Carolina, in September, 1975, contained a large milliped, apparently of "*Spirobolus*" type (*Narceus*).

Three of my specimens contained reptiles (6.9/4.8 percent): 1 *Carphophis amoenus*, 1 *Diadophis punctatus* and 1 *Ophisaurus* sp. Both snakes had been eaten by copperheads in their first year of life. Remains of a young bird, possibly a Rufous-sided Towhee or Blue Grosbeak, were found in another stomach.

Two copperheads had taken especially sizable meals, 36 and 62 percent of their weights. In only five cases out of the 35 did stomachs contain more than one food item.

Snakes examined were from Anson, Brunswick, Burke, Caldwell, Columbus, Mecklenburg and Robeson cos., NC, and Colleton, Dillon and Horry cos., SC.

Agkistrodon piscivorus piscivorus, Eastern Cottonmouth.

Three specimens, from Horry and Berkeley counties, South Carolina, contained food. A 395 mm TL snake had a small frog of the genus *Rana*,

and a 600 mm TL specimen contained a shrew, *Cryptotis parva*. The intestine of a 380 mm TL specimen contained mammal fur and smooth snake scales.

Crotalus horridus, Timber Rattlesnake.

Three specimens from Alleghany and Buncombe counties, North Carolina, had eaten four mammals: 2 *Microtus pennsylvanicus*, 1 *Tamias striatus* and 1 *Ochrotomys nuttalli*.

Two young snakes, of what may or may not be recognized as the subspecies *C. h. atricaudatus*, contained a young *Peromyscus* sp. and a *Microtus pennsylvanicus*. A larger snake, 140 cm TL, had eaten a *Sciurus carolinensis*. These last snakes were from Brunswick and Burke cos., NC, and Chesterfield Co., SC.

DISCUSSION

Neill and Allen (1956) commented rather vigorously and dogmatically concerning "secondarily ingested food items" in snake stomachs. Their warning was valid, but their paper, which considerably overstated the case, is still being quoted uncritically. It is evident that some early workers, e.g. Surface (1906), made no effort to distinguish between primary, and possible secondary, items. No doubt there have been occasional oversights and misinterpretations since those times. However, to imply that a copperhead or black racer (among others) may not take arthropods at times seems extremely questionable, if not actually absurd. Savage (1967) recorded 29 cicadas in 42 copperheads from the Great Smokies region, and his study apparently did not include a season of periodical cicada emergence. The finding of centipedes in southern *Sistrurus* by Hamilton and Pollack (1955) probably should have suggested to the rest of us that we know too little about that snake. Although it involves a totally different small viper, a figure in Copeia (1967, p. 224) is thought provoking in this connection.

Heavier skeletal parts of some beetles are, of course, highly resistant to digestion by snakes. However, softer materials (e.g. moths; caterpillars; cicada nymphs; abdominal regions of spiders and of mantids and other orthoptera; small centipedes) appear to pose no appreciable problem.

Neill and Allen (1956) also referred to lengthy retention of indigestible food residue in the colon of such large snakes as *Python* and *Eunectes*. I may not be qualified to comment on this, since my chief experience has been with small, eastern forms, especially *Nerodia*. However, as I showed in a later paper on water snake food (Brown 1958), such retention occurs when a snake is without food for an extended period. A meal, or sometimes even a massive drink of water, may stimulate it to pass such

previous residue. A specimen that was feeding regularly and frequently would pass all residue through without appreciable delay. This feature, using a "marker" meal, was found to be useful in roughly gauging "total digestive time" at average summer temperatures. The later ingestion of a "chaser" meal helps to ensure that the marker meal does not dally along the way. The observer, of course, must experiment a bit to see whether the marker material is all being voided at one time.

ACKNOWLEDGMENTS. — I am indebted to many persons for the contribution of specimens, especially the late J. Oscar Gant and Rob B. Knox, and also to Ruben T. McIntosh, Tom Daggy, James D. Brown, James Gant, C. K. Bartell and John Lammers. Tom Daggy was kind enough to identify many of the insects. Some of the field trips on which specimens were collected were partially supported by Davidson College Faculty Research Funds.

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Accepted 4 January 1979

The Status of the Outer Banks Kingsnake, *Lampropeltis getulus sticticeps* (Reptilia: Serpentes: Colubridae)

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ABSTRACT.—The Outer Banks Kingsnake, described as *Lampropeltis getulus sticticeps* by Barbour and Engels (1942), is analyzed. Aspects of color pattern, proportions, and scutellation characteristic of *L.g. floridana* and *L.g. getulus* are found in this population, with no characteristics unique enough to warrant the status of subspecies. Instead, it should be recognized as a probably relictual, intergrade population.

The taxonomic status of kingsnakes on the Outer Banks of North Carolina has been a source of controversy since the description of *Lampropeltis getulus sticticeps* by Barbour and Engels (1942), and its subsequent relegation to the status of "problematical" by Wright and Wright (1957). During the course of my work on *L. getulus* (Blaney 1971, 1977), I examined a series of specimens from the Outer Banks that, when compared with other material from throughout the range of the species, showed the population to be highly variable and to exhibit characteristics of both *L.g. getulus* and *L.g. floridana*. I therefore concluded that it should not receive nomenclatural recognition. These conclusions, data and photographs were provided to J.D. Lazell in 1971 for consideration at his request. However, on the basis of several new specimens, Lazell and Musick (1973) reported that *L.g. sticticeps* should be regarded a valid subspecies. The purpose of this paper is to reexamine the data and reconsider the interpretation of the kingsnake inhabiting the intra-Capes zone.

That this Outer Banks population is unusual is not at all in question. The unique environment of the area, admirably described by Lazell and Musick (1973), surely contributes to the maintenance of its integrity by isolation. What is in question is the level of differentiation of the population relative to the species as a whole, and the causes of its distinctiveness.

Lazell and Musick (1973) described the basic pattern of *L.g. sticticeps* as "exactly like that of the nominate *L.g. getulus*: bold white or yellow (usually cream) transverse bars cross the dorsum and are connected laterally," except that in *L.g. sticticeps* light spotted scales occur in the dark interspaces above scale row eight. They further stated that the spotted patterns of *L.g. sticticeps* and *L.g. floridana* differ in that "in *L.g. floridana* the light dorsals in the dark interspaces result primarily from progressive lightening of each dorsal scale basally" while the spots are

"well-centered" in *L.g. sticticeps*. All specimens that I examined from the Outer Banks have the basal spotting characteristic of *L.g. floridana* (Blaney 1977). Even the dorsal view of the head of the Outer Banks specimen illustrated by Lazell and Musick (1973) shows this type of spotting.

Lazell and Musick (1973) stated that "the most striking feature of *L. g. sticticeps* is the *Pituophis*-like head shape." They admitted difficulty in quantifying this observation, and suggested that it is the rostral shape and proportion that imparts this appearance. The rostral shape does differ from that found on most individuals of *L.g. getulus* from adjacent populations, but this is a highly variable character. It is, however, the same as in *L. g. floridana*. Lazell and Musick (1973) dismissed this similarity as "coincidental, because the head shapes are not similar." The similarity in rostral shape cannot arbitrarily be dismissed; head shapes are, indeed, similar. Head shape varies individually in the Outer Banks population, in *L.g. getulus*, and in *L.g. floridana* (Fig. 1). The comparative head photographs provided by Lazell and Musick (1973) represent the extremes of this variation. They also stated that *L.g. sticticeps* "is proportionately stouter and heavier than is nominate *getulus*, and this reflected in average scale counts: dorsal rows and ventrals." Neither of these characteristics reflects stoutness, a relative term at best. Stout specimens can be found in *L.g. getulus* and *L.g. floridana* at the extremes of variation of both characteristics (Blaney 1977). However, the number of dorsal scale rows is significant. *Lampropeltis g. getulus* have a maximum of 21 dorsal scale rows throughout its range; *L.g. floridana* has 23 dorsal scale rows (Blaney 1977). Another indication of *L.g. floridana* influence on the Outer Banks population is that at least two specimens have more than 21 dorsal scale rows.

Lazel and Musick (1973) presented three lines of evidence that point away from *L.g. floridana* influence in *L.g. sticticeps*. First, *L.g. sticticeps* has fewer transverse light bars. I have shown geographic variation in the number of dorsal bands (Blaney 1977). The Outer Banks population averages 25.3 dorsal bands compared with 21.5 and 22.6 on the adjacent mainland, and 23.8 to the north on the Virginia coast. Southern Florida *L.g. floridana* average about 54; *L.g. getulus* in northern Florida have the lowest average of 18, and 32 is the high in the northern extremes of the range. Intergrade populations of *L.g. getulus* and *L.g. floridana* in central Florida average in the 40s, but a disjunct *L.g. floridana* population in extreme northeastern Florida averages 25. Clearly. the number of dorsal bands does not exclude the possible influence of *L.g. floridana*.

Their second argument is that "*L.g. sticticeps* strongly diverges from *floridana* and nominate *getulus* in ventral counts. . ." However, analysis of

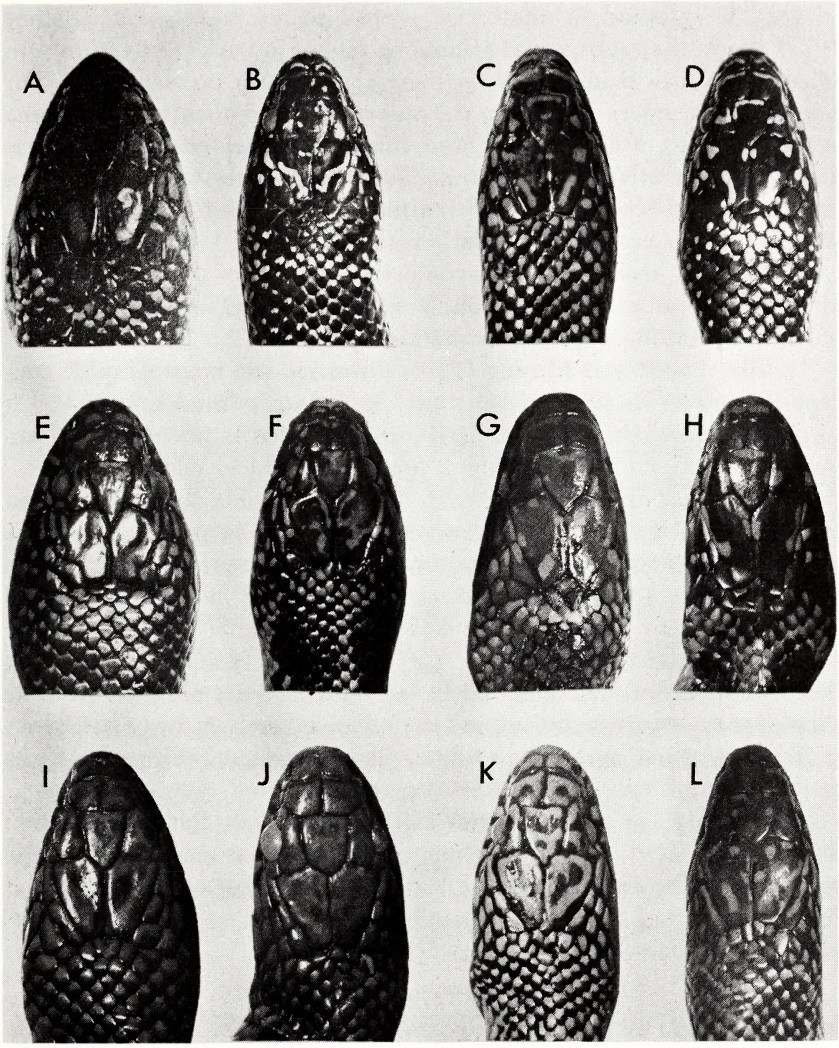

Fig. 1. Variation in head shape of adult *Lampropeltis getulus*. *TOP ROW:* Outer Banks Kingsnakes, North Carolina—*A*. Dare Co., Hatteras (Museum Comparative Zoology 128104); *B*. Carteret Co., Core Banks, ca 24 km n Cape Lookout (North Carolina State Museum 12450); *C*. Dare Co., Hatteras Island, Buxton (NCSM 10912); *D*. Carteret Co., Core Banks, 24 km n Cape Lookout (NCSM 12449). *MIDDLE ROW: Lampropeltis getulus getulus,* Florida—*E*. Gulf Co., 16 km n Apalachicola (R.M. Blaney coll. 4997); *F*. Gulf Co., 8 km e Wewahitchka (RMB 4998); *G*. Duval Co., 3.7 km s Ponte Verde (RMB 4937); *H*. Jefferson Co., Wacissa (RMB 4578). *BOTTOM ROW: Lampropeltis getulus floridana,* Florida—*I*. Dade Co. (RMB 4588); *J*. Collier Co., Immolakee (RMB 4773); *K*. Dade Co., Homestead (RMB 4888); *L*. Palm Beach Co., Belle Glade (RMB 4624).

geographic variation in number of ventral scutes in *L. getulus* (Blaney 1977) shows that subspecies definitions relying on such counts are unreliable. Ecological influences on these counts must be considered. For example, kingsnakes inhabiting the pinewoods of southeastern Louisiana average 212 ventrals, while those inhabiting lowlands in the same geograhic area average 206 ventrals. Such considerations would account for the lower average number of ventrals (203) in the Outer Banks population than in mainland populations to the east (210) and north (209), and certainly should not be compared with the average (215) of kingsnakes from southern Florida. Ventral count comparisons are useful only for delimiting populations, not subspecies.

Thirdly, Lazell and Musick (1973) dismissed the biogeographic concept (Blaney 1971, 1977) of dynamic populations in their statement, "It would be remarkable if a southern form extended hundred [sic] of km north of its present range during a presumably colder climatic regime." Such northward expansion, however, might be possible along the exposed continental shelf where any climate changes would be moderated by the ocean. Nonetheless, it was not my contention that southern forms migrated north and outcompeted northern forms to inhabit the exposed continental shelf. Rather, I gave evidence (Blaney 1971, 1977) that *L.g. getulus* was derived from primitive *L.g. floridana* stocks and suggested that the nominate form differentiated in the northern part of its range to its present characteristics. In certain isolated areas, such as the Outer Banks of North Carolina, and Sapelo Island, Georgia, some of the genetic traits of the parental form (*L.g. floridana*) persist.

In summary, no characteristics exist in the Outer Banks population described as *L.g. sticticeps* that make it unique enough for taxonomic recognition. The characteristics present are only those of *L.g. getulus* and *L.g. floridana*, and therefore it should be recognized as a probably relictual, intermediate (= intergrade) population.

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Accepted 22 November 1978

Notes on the Natural History of the Terrestrial Leech, *Haemopis septagon* Sawyer and Shelley (Gnathobdella: Hirudinidae)

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ABSTRACT.—The terrestrial leech, *Haemopis septagon* Sawyer and Shelley, inhabits moist floodplains near water sources in North Carolina and appears to be widespread in the Coastal Plain and eastern Piedmont of the state. Large earthworms seem to be the primary food source. Some individuals display light yellowish stripes along the lateral margin, and one reddish juvenile has been collected, possibly reflecting a recessive genotype for color. Immature specimens have been encountered in April and are characterized by a flattened female gonopore and reduced body size. Anatomical, ecological, and geographical similarities with *H. terrestris* (Forbes) suggest a close phylogenetic relationship for the two land leeches of North America.

The terrestrial leech, *Haemopis septagon* Sawyer and Shelley, inhabits the Coastal Plain and eastern Piedmont Plateau provinces of the Carolinas and Virginia (Sawyer and Shelley 1976). The only other land leech in the United States, *Haemopis terrestris* (Forbes), occurs in the Mississippi and Ohio River valleys from the southern Great Lakes south to Louisiana and eastward along the Gulf Coast to Gainesville, Florida (Sawyer 1972, Sawyer and Shelley 1976). The latter species occurs in damp soil under rocks and logs and feeds on large earthworms (Forbes 1890, Sawyer 1972). Little is known about its life history. Sawyer and Shelley (1976) described the anatomy of *H. septagon*, but because the number of specimens was limited, and most were preserved without habitat data, no ecological or reproductive information was provided.

In the past few years we have collected a number of specimens of *H. septagon* in North Carolina, especially from the upper Neuse River Basin of Wake County, and present the following observations on its habitat, life history, and color variation to supplement the popularized account by Shelley (1977). Six individuals were immature, as revealed by overall size and the condition of the female gonopore.

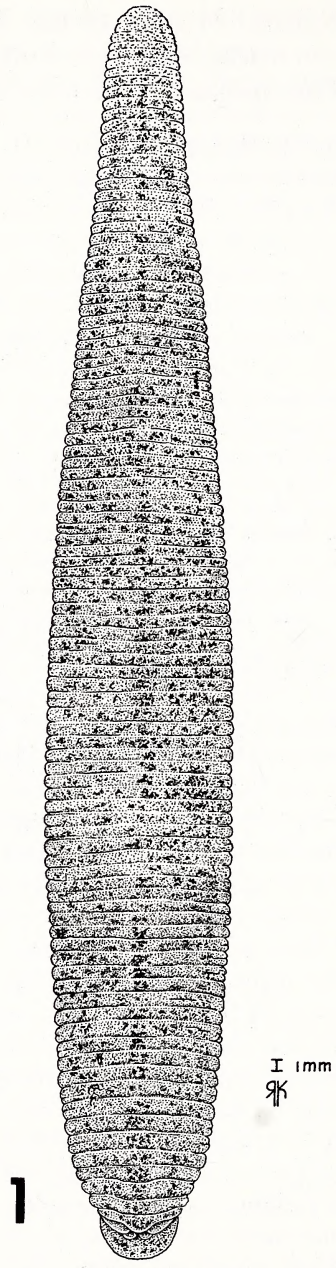

Fig. 1. Dorsal view of adult *Haemopis septagon,* specimen from 0.5 km nw Falls, Wake Co., North Carolina.

As described by Sawyer and Shelley (1976), the dorsal pigment pattern of *H. septagon* (Fig. 1) is typically dark olive-green with a faint, longitudinal middorsal stripe and numerous scattered black flecks; the venter is lighter olive-green without flecks. Variation in this pattern has been noted among the individuals reported below. Juveniles and some adults also display yellowish marginal stripes, which are most conspicuous on the leech from Duplin County (NCSM P177) (see locality data below). Here the pattern resembles that exhibited by *H. terrestris* (Sawyer 1972, Fig. 13F). A reddish immature leech was collected in a sample containing five additional fully pigmented juveniles of the same size and, presumably, the same age. This individual is uniformly red on both surfaces, possibly because of blood in the underlying musculature, and the eyes, middorsal stripe, and flecks are faintly visible. Its color is similar to that of an albino specimen of *Dina absoloni* Johansson (Erpobdellidae) from a cave in Yugoslavia (Johansson 1913). Other reports of albino leeches are of white specimens, however, and include an unidentified species of *Philaemon* (Haemadipsidae) from a cave in New Guinea (Ewers 1974), and *Erpobdella punctata punctata* (Leidy) (Erpobdellidae) from a lake in southern Michigan (Sawyer 1970). It is noteworthy that the juvenile *H. septagon* was collected with five fully pigmented juveniles of apparently the same age. Thus, its reduced pigmentation may be reflective of a recessive genotype for color.

The six juveniles mentioned above and two adults were collected on 19 April 1976 in northern Wake County. The immatures were generally smaller than the adults in physical dimensions, and the female gonopore was flattened and contiguous with the ventral surface instead of elevated and nipple-shaped. The gonopores conformed to the species description in location, the male being 24 annuli posterior to the oral sucker and 6½-7 annuli anterior to the female opening. Elevation of the female gonopore is apparently achieved later in development and is not characteristic of young individuals.

The habitat of *H. septagon* is similar to that mentioned earlier for *H. terrestris*. The leech is usually encountered on moist floodplains in deciduous forests; the areas immediately surrounding floodplain ponds and backwaters of rivers and creeks seem to be preferred. Most individuals are found under or inside partially buried, rotting logs, and some have been taken from wet leaf litter. Several specimens were collected from seepage areas on hardwood slopes. All of the leeches have been found close to but not in standing water, in areas also inhabited by large earthworms. During preservation some specimens regurgitated portions of earthworms, which appear to be their primary food.

The following new localities, all in North Carolina, are reported for *H.*

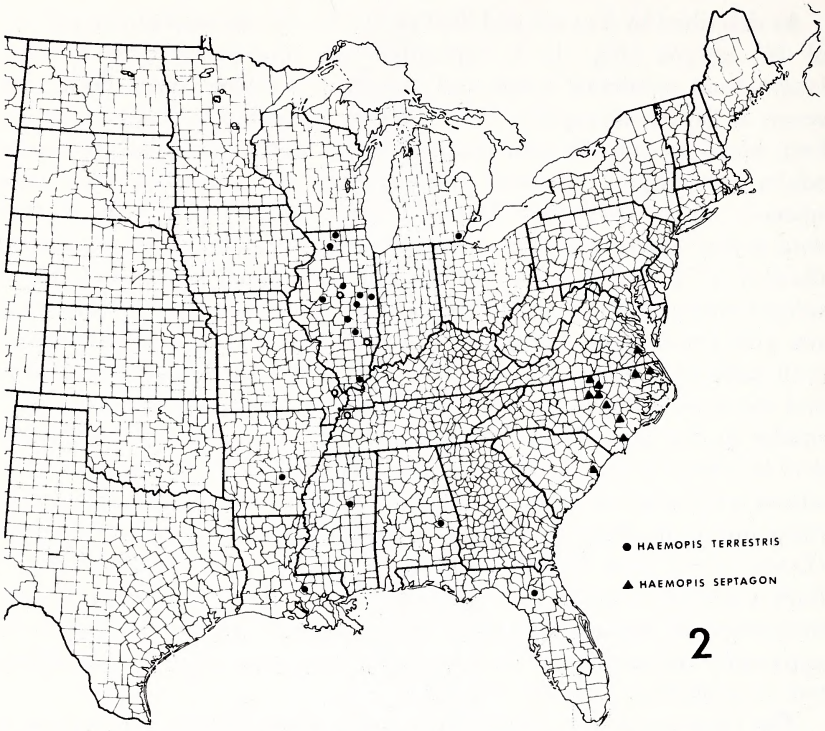

Fig. 2. Distribution of the terrestrial leeches of the United States, taken in part from Sawyer (1972) and Sawyer and Shelley (1976). Each circle represents a single collecting locality except for those sites occurring close together, which are represented by one symbol. Open circles are based on literature records believed to be valid.

septagon; coupled with those listed by Sawyer and Shelley (1976) they indicate that the species is widespread in the Coastal Plain of the state. The leech is common at the type locality in spring and summer. All specimens referred to are deposited in the invertebrate collections of the North Carolina State Museum of Natural History (NCSM).

Person Co.—12.8 km ne Roxboro, off co. rd. 1518 near Mayo Cr. (Roanoke dr.), 1 adult, 5 April 1977, A.L. Braswell (NCSM P223). *Granville Co.*—4.8 km se Creedmoor, along co. rd. 1721, 1.9 km e jct. co. rd. 1722, under log near trib. Robertson Cr. (Neuse dr.), 1 adult, 27 April 1977, J.E. Cooper and R.E. Ashton (NCSM P227). *Durham Co.*—9.9 km sw Durham, along NC hwy 54, 0.2 km e jct. NC hwy. 751, floodplain Third Fork Cr. (Cape Fear dr.), 1 adult, 11 July 1975, R.M. Shelley and J.C. Clamp (NCSM P126). This site is about 1.6 km e of the type locality. *Wake Co.* (all Neuse dr.)—along co. rd. 1918, 0.3 km se jct. co. rd. 1909,

under log in seepage area near small trib. Newlight Cr., 1 adult, 18 February 1976, A.L. Braswell and N. Murdock (NCSM P175); 5.6 km n Cary, along US hwy I-40, 0.5 km nw jct. co. rd. 1795, floodplain Crabtree Cr., 2 adults, 28 March 1976, A.L. Braswell and N. Murdock (NCSM P178); near Neuse R. at NC hwy. 98, 1 adult, 19 April 1976, A.L. Braswell and D.L. Stephan (NCSM P181); 0.5 km nw Falls, under wet leaves in seepage area, about 15 cm from water and 46 m from Neuse R., 1 adult, 18 February 1976, A.L. Braswell and N. Murdock (NCSM P176); 7.7 km sw Wake Forest, along co. rd. 2000 near Neuse R., 2 adults, 6 immatures (one reddish in color), 19 April 1976, A.L. Braswell and D.L. Stephan (NCSM P180). *Johnson Co.*—Smithfield, in lawn or plant bed at 831 Ward St. (Neuse dr.), 1 adult, 10 April 1977, M. Dublin (NCSM P224). *Duplin Co.*—13.6 km ne Kenansville, Goshen Swamp (Cape Fear dr.) near NC hwy. 11, 1 adult, 6 March 1976, B.S. Martof and J.H. Reynolds (NCSM P177). *Pasquotank Co.*—Elizabeth City, crawling on ground near service station (Pasquotank dr.), 1 adult, 8 March 1975, R. Mann (NCSM P186).

The similarities between *H. septagon* and *H. terrestris* are noteworthy. In addition to terrestrial habits they have comparable color patterns, with a dark base color and darker middorsal and lighter lateral stripes. These markings are better defined in *H. terrestris* than in *H. septagon*. External differences include the configuration of the adult female gonopore (elevated in *H. septagon,* flattened in *H. terrestris*) and the annular separation of the gonopores (6½-7 annuli in *H. septagon,* 5-5½ annuli in *H. terrestris*). The Carolina species seems to be more dependent upon moisture and is rarely found more than a few meters from a water source. According to Sawyer (1972), *H. terrestris* is usually found "well away from the water" and thus seems to be better adapted to terrestrial life. Anatomical, ecological, and geographical (Fig. 2) comparisons suggest that the two may be sister species only one step removed from a common ancestor. Conceivably, either could have been the stock from which the other was derived, existing relatively unchanged since the time of divergence. They may prove to occur sympatrically in Georgia and southern South Carolina, and future efforts should be directed toward determining the nature of the terrestrial leech populations of these areas.

ACKNOWLEDGMENTS. — We are grateful to Roy T. Sawyer for his constructive comments on an early draft of the manuscript. We also thank the persons cited in the text for assistance in securing specimens of *H. septagon.* Figure 1 was prepared by Renaldo G. Kuhler, North Carolina State Museum scientific illustrator.

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Accepted 8 November 1978

New Records of the Salamanders *Ambystoma talpoideum* (Holbrook) and *Hemidactylium scutatum* (Schlegel) in North Carolina (Amphibia: Ambystomatidae and Plethodontidae)

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ABSTRACT.—Disjunct populations of *Ambystoma talpoideum*, a salamander which primarily occurs in the southeastern Coastal Plain and the Mississippi Valley, were found in Union and Surry counties in the Piedmont. They are North Carolina's first verified records from east of the eastern Continental Divide. *Hemidactylium scutatum*, formerly known in North Carolina only from a few localities in the Piedmont and Mountains, was found at three localities in the Coastal Plain of the state. These are the first records for the species from this physiographic province south of Virginia. Several other sites heretofore considered disjunct now seem to be part of a more or less continuous range.

Knowledge of a species' distributional boundaries is a prerequisite for understanding the environmental factors that govern its range. *Ambystoma talpoideum* and *Hemidactylium scutatum* have ranges that are imperfectly known. Both species apparently have disjunct populations that suggest past ranges different from those that now exist (Smith 1957, Conant 1960, Dowling 1956). Shoop (1964) and Neill (1963), respectively, provided reviews of the *A. talpoideum* and *H. scutatum* literature. *Ambystoma talpoidum* is considered a southern species with northern disjunct populations, whereas *H. scutatum* is thought to be a northern species with southern disjuncts. This paper summarizes previously reported localities in North Carolina, adds new records, and provides significant range extensions for both species.

Ambystoma talpoideum

Ambystoma talpoideum, the Mole Salamander, is chiefly an animal of the southeastern Coastal Plain and the Mississippi Valley. In the northern

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portion of its range it is known from several disjunct localities (Shoop 1964, Conant 1975). In North Carolina, *A. talpoideum* has been reported only from the southwestern Mountains: *Cherokee Co.*—Huheey and Stupka (1967) [= 19.3 km w Murphy; Field Museum of Natural History = FMNH, 10 specimens]; *Henderson Co.*—(Fowler and Dunn 1917; Academy of Natural Sciences of Philadelphia, 1 specimen). Bishop (1943) mentioned its occurrence in Transylvania County, but we have been unable to locate voucher specimens.

Additional North Carolina *A. talpoideum* localities, with numbers of specimens following museum designations, are: *Buncombe Co.*—37.0 km ne Brevard (Charleston Museum = ChM, 30), 11.3 km ssw Asheville (University of Michigan Museum of Zoology = UMMZ, 1 gilled), 12.1 km sw Asheville (North Carolina State Museum of Natural History = NCSM, 16), 3.6 km nnw town of Avery Creek (NCSM, 6 + 40 gilled); *Cherokee Co.*—8.0 km w Murphy (ChM, 11), 6.4 km w Murphy (ChM, 6), 9.3 km sw Murphy (University of Kansas = KU, 1), 8.0 km sw Murphy (NCSM, 14 gilled); *Macon Co.* —22.5 km wsw Franklin (NCSM, 6 + 185 gilled); *Surry Co.* —Pilot Mountain State Park (NCSM, 5 + 11 gilled); *Union Co.* —26.2 km ne Monroe (NCSM, 10 + 131 gilled). The Buncombe County records probably are from the same locality ("Sandy Bottom"), reported in various ways by different collectors. Investigation of the Cherokee County records revealed that the probable locality for all specimens previously (Huheey and Stupka 1967) and herein reported, with the possible exception of the KU specimen, is 8.0 km southwest of Murphy. All North Carolina localities are shown in Fig. 1.

The specimens from Union and Surry counties represent the first North Carolina records east of the Eastern Continental Divide. Both localities are in the Yadkin-Pee Dee River drainage of the Piedmont. *Ambystoma talpoideum* is not known from this drainage in South Carolina. The Surry County locality, only 31 km south of the Virginia border, is the most northeastern record for the species. It is about 250 km north of the nearest South Carolina locality near Columbia (Shoop 1964), and 212 km northeast of the nearest mountain locality near Asheville, Buncombe County.

The North Carolina *A. talpoideum* localities apparently are disjunct and represent relict populations from a time that favored a more northern distribution. Smith (1957) attributed disjunct northern populations of *A. talpoideum* in the Prairie Penninsula region to the post-Wisconsin "Climatic Optimum" and the following "Xerothermic" period. The factors that Smith discussed may explain the North Carolina populations. However, the climate of the post-Wisconsin period and its effects on the southeastern United States are far from fully understood (Wright 1976).

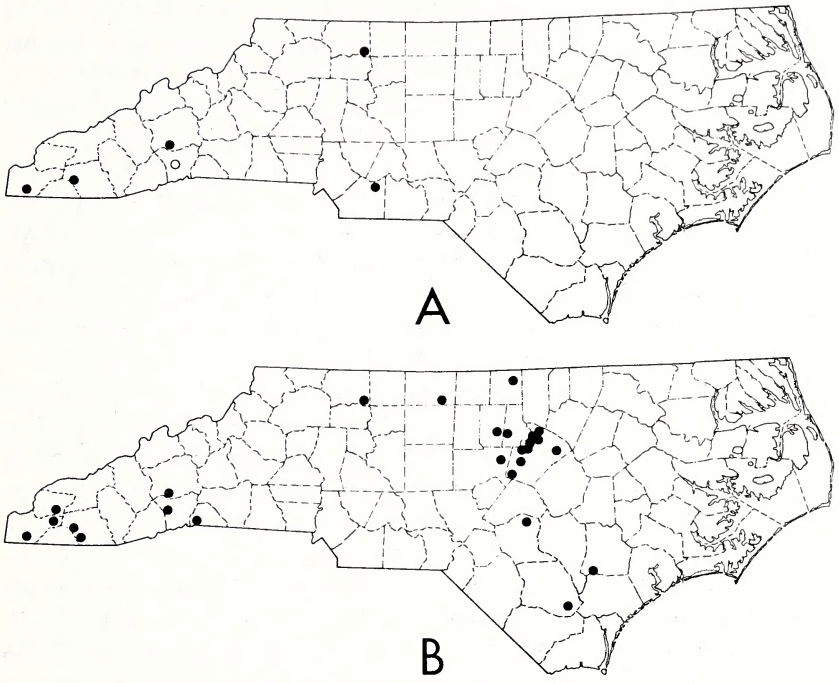

Fig. 1. Distribution of (A) *Ambystoma talpoideum* and (B) *Hemidactylium scutatum* in North Carolina. A single symbol may represent several clustered localities. The open circle on (A) indicates a county record without precise locality data.

Hemidactylium scutatum

Hemidactylium scutatum, the Four-toed Salamander, has a somewhat continuous range in the northeastern states and is relatively common there. Conant (1975) considered it absent from the Atlantic Coastal Plain south of Virginia, and it apparently is rare in the southeastern states. The species was formerly known in North Carolina only from a few localities in the Piedmont and Mountains: *Cherokee Co.*—near Andrews (Huheey and Stupka 1967; FMNH, 2); *Durham Co.*—Duke Forest (Gray 1941; UMMZ, 1); *Graham Co.*—near Topton (Huheey and Stupka 1967; UMMZ, 1); *Wake Co.*—8 mi. [12.9 km] nw Raleigh (Hurst 1964; NCSM, 1). Recent discoveries indicate that it is more widely distributed.

Additional North Carolina localities for *H. scutatum* are: *Bladen Co.*—10.5 km ese Kelly (NCSM, 3); *Buncombe Co.*—3.6 km nnw town of Avery Creek (NCSM, 3 + 1 larva); *Chatham Co.*—2.2 km ssw Wilsonville

(NCSM, 7 + 42 larvae); *Cherokee Co.*—8.0 km sw Murphy (NCSM, 14 larvae), 2.0 km ese Andrews (KU, 10); *Cumberland Co.*—near Linden (NCSM, 1); *Duplin Co.*—4.2 km w Wallace (NCSM, 2); *Henderson Co.*—2.4 km w Etowah (NCSM, 1); *Macon Co.*—22.5 km wsw Franklin (NCSM, 9 + 7 larvae), 16.9 km sw Franklin (NCSM, 1); *Orange Co.*—9.7 km nnw Chapel Hill (Duke University, 9 + larvae; NCSM, 2); *Person Co.*—3.2 km se Bethel Hill (NCSM, 2), 12.9 km ne Roxboro (NCSM, 2); *Polk Co.*—near Tryon (National Museum of Natural History = USNM, 1); *Rockingham Co.*—12.1 km s Reidsville (NCSM, 1); *Surry Co.*—Pilot Mountain State Park (NCSM, 4); *Wake Co.*—14 additional localities (NCSM, 105). Most specimens are females that were collected with their eggs. All localities are shown in Fig. 1.

The Bladen and Duplin County localities are 144 km south-southeast and 126 km southeast respectively, of the nearest Piedmont locality in Wake County. Excluding an old and questionable record from Charleston, South Carolina (Neill 1963), the localities in Bladen, Duplin, and Cumberland counties are the first from the Atlantic Coastal Plain south of Virginia.

More field work is needed before any definite conclusions can be made about disjunct or relict populations of *H. scutatum*. Since Neill (1963), several authors have provided additional records of *H. scutatum* in the south: Mount (1975, Alabama); Dundee (1968, Mississippi); Fugler and Folkerts (1967, Florida); Carter (1968, Oklahoma); and Watkins (1969, Missouri). These records are reflected in Conant's range map (1975). Although somewhat restricted in its habitat requirements, this secretive salamander appears more widely and uniformly distributed than previously thought. Several sites heretofore considered disjunct now seem to be part of a more or less continuous range.

ACKNOWLEDGMENTS. — We thank Bernard S. Martof, N.C. State University, for his criticisms of the manuscript, and William M. Palmer, N.C. State Museum, for his help with the manuscript and for providing information on major museum holdings. Drs. R.C. Bruce and J.R. Bailey contributed much to our current knowledge of *H. scutatum* in the state. S. Alford, J.W. Braswell, Jr., J. Brellenthin, J. Clayton, E.E. Flowers, J. Gillespie, D. Lee, D. Lockwood, G. Mortoro, J.C. Nicholls, Jr., J.H. Reynolds, F. Scott, R.C. Shoop, D.L. Stephan, and R. Yates helped in various ways. The Highlands Biological Station, Highlands, was a base of operations for some of the field work.

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Accepted 16 November 1978

An Albino Sculpin from a Cave in the New River Drainage of West Virginia (Pisces: Cottidae)

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ABSTRACT. — An albino Banded sculpin, *Cottus carolinae*, with atypical morphological features, is reported from Buckeye Creek Cave, Greenbrier County, West Virginia. This is the first report of albinism in the genus. One atypical feature of the specimen is presence of a frenum, a structure unknown in any member of the family Cottidae. Other atypical features include enlargement of the cephalic canal pores and fusion of the postmandibular pores, and dorsal spine and pelvic fin ray counts that are unusual for a member of the *C. carolinae* species group. The atypical features are described and compared with those of normally pigmented *C. carolinae*, which also occur in the cave.

INTRODUCTION

A male albino Banded sculpin (Fig. 1), 67 mm standard length (SL), was collected in Buckeye Creek Cave by J. A. Stellmack on 3 September 1967. We are reporting this specimen as the first record of albinism in the genus *Cottus*, family Cottidae. It is somewhat surprising that this condition has not previously been reported for sculpins considering their frequent occurrence in subterranean waters. The specimen is of particular interest since it has several atypical morphological features in addition to the albinistic condition.

Buckeye Creek Cave is located approximately 4 km southwest of Renick, Greenbrier County, West Virginia. The entrance to the cave is in a shallow limestone sink in a hillside alongside a pasture. A small stream 1 to 2 m wide which flows into the cave appears to be a tributuary of Spring creek, Greenbrier River drainage. This drainage is developed on limestone and has many subterranean streams. The albino sculpin was collected in the aphotic zone of the cave, approximately 200 m from the entrance. It was sighted and taken in an open area in clear water approximately 15 cm deep over a gravel bottom. At the time of capture the body

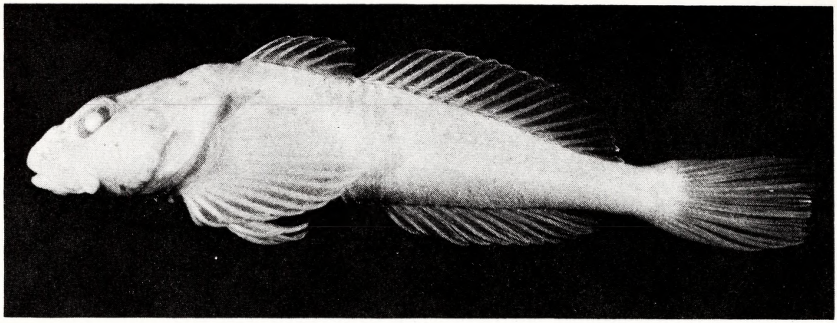

Fig. 1. Albino Banded sculpin, *Cottus carolinae*, (67 mm SL) from Buckeye Creek Cave, Greenbrier County, West Virginia, collected 3 September 1967.

was white to cream colored, without any dark pigment. Eye color was not noted at that time (J. A. Stellmack, pers. comm.).

On 7 August 1970 we visited Buckeye Creek Cave to search for additional specimens of *Cottus*. No albinos were seen, but 48 normally pigmented *Cottus carolinae*, ranging from 18 to 91 mm SL, were collected inside and outside the cave. We found specimens to a distance of 400 m inside the cave, which was as far as we explored.

RESULTS AND DISCUSSION

Other atypical features present in the Buckeye Creek Cave albino include: (1) a frenum; (2) enlargement of the cephalic canal pores and fusion of the postmandibular pores; and (3) dorsal spine and pelvic fin ray counts that are atypical for a member of the *Cottus carolinae* species group (Table 1). The presence of a frenum in the albino sculpin is most unusual. This condition is not known to occur in any other member of the genus *Cottus* or in the family Cottidae.

Enlargement of the cephalic canal pores and fusion of the postmandibular pores may be associated with the albinistic condition, but are more likely results of conditions in the cave environment. McAllister (1968) reported enlarged pores on sculpins from poorly lighted environments, such as deep lakes and muddy water, compared with sculpins in well lighted environments. Fusion of the two postmandibular pores into a single large pore is a condition that rarely occurs in surface dwelling sculpins. Seven of the 20 specimens (29-91 mm SL) of the 48 normally-pigmented specimens taken inside Buckeye Creek Cave and outside around the entrance had the postmandibular pores fused into a single pore.

Table 1. Frequency distribution of numbers of fin rays and lateral line pore counts for *Cottus bairdi* and *C. carolinae* from the New River drainage (Robins 1954); a recent collection of *C. carolinae* from Buckeye Creek Cave (New River drainage); and an albino *C. carolinae* from Buckeye Creek Cave.

	Dorsal spines				
	6	7	8	N	$\bar{X}$
Cottus bairdi					
New River drainage		70	64	134	7.48
Cottus carolinae					
New River drainage		27	69	96	7.72
Buckeye Creek Cave		28	2	30	7.07
Albino	1			1	6.00

	Dorsal rays					
	15	16	17	18	N	$\bar{X}$
Cottus bairdi						
New River drainage	11	68	55	2	136	16.35
Cottus carolinae						
New River drainage		46	50	1	97	16.54
Buckeye Creek Cave	3	25	2		30	15.97
Albino		1			1	16.00

	Dorsal spines plus rays						
	22	23	24	25	26	N	$\bar{X}$
Cottus bairdi							
New River drainage	7	32	65	27		131	23.86
Cottus carolinae							
New River drainage		12	36	42	1	91	24.35
Buckeye Creek Cave	3	23	4			39	23.03
Albino	1					1	22.00

	Anal rays					
	11	12	13	14	N	$\bar{X}$
Cottus bairdi						
New River drainage	6	75	52	2	135	12.37
Cottus carolinae						
New River drainage	1	36	59	1	97	12.62
Buckeye Creek Cave	2	13	14		29	12.41
Albino		1			1	12.00

Table 1 (Continued)

	Pectoral rays (left and right fins)							
	13	14	15	16	17	18	N	$\bar{X}$
Cottus bairdi								
New River drainage	11	96	185	20			312	14.69
Cottus carolinae								
New River drainage			3	47	129	17	196	16.88
Buckeye Creek Cave				35	25		60	16.42
Albino			1	1			2	15.50

	Pelvic rays (left and right fins)			
	3	4	N	$\bar{X}$
Cottus bairdi				
New River drainage	37	235	272	3.86
Cottus carolinae				
New River drainage		182	182	4.00
Buckeye Creek Cave		60	60	4.00
Albino	2		2	3.00

	Lateral line pores								
	18	19	20	21	22	23	24	25	26
Cottus bairdi									
New River drainage	1	6	8	10	18	25	14	11	5
Cottus carolinae									
New River drainage							2	6	7
Buckeye Creek Cave							2	3	5
Albino								1	

	Lateral line pores								
	27	28	29	30	31	32	33	N	$\bar{X}$
Cottus bairdi									
New River drainage								100	22.68
Cottus carolinae									
New River drainage	21	38	8	2	2	8	3	97	28.04
Buckeye Creek Cave	5	1						16	
Albino								1	25.00

Two atypical fin ray counts were observed in the albino. The low dorsal spine count (6) is unusual for species of the *Cottus bairdi* or *C. carolinae* complex. Three pelvic rays in the albino are atypical for the *C. carolinae* complex, but is not unusual for, and can be characteristic of, some species of the *C. bairdi* complex. All fin rays except caudal rays were unbranched, which is the usual condition in the genus. Relyea and Sutton (1973) reported a cave population of Yellow bullheads, *Ictalurus natalis*, in which some individuals had no pelvic fins while others had a deformed caudal fin and a deformed, reduced or absent adipose fin. These bullheads were somewhat depigmented but not albinistic.

The preopercular armature of the albino sculpin consists of one moderate-to-large upturned spine with two smaller spines below it. The dentition is well developed, with the palatine patch almost touching the vomerine patch. In length the palatine patch is about equal to the width of the vomerine patch. The preopercular armature and dentition are typical for *C. carolinae*.

Body proportions of the albino fall within the range of variation of both *C. carolinae* and *C. bairdi* as reported by Robins (1954). Body proportions, expressed as thousandths of standard length, are: head length/346; eye length/82; lateral line length/845; body depth/224; caudal peduncle depth/82; caudal fin length/228; pelvic fin length/187; pectoral fin length/262.

There have been numerous reports of albinism in fishes (see Dawson 1964, 1966, 1971), most of which reported the albinistic condition but did not note any unusual or atypical morphological features associated with albinism. Bridges and Limbach (1972) demonstrated through breeding tests that albinism in Rainbow trout, *Salmo gairdneri*, is a simple autosomal recessive character. They found no significant pleiotropic effect of the mutant gene.

Speciation can be expected to be greater in the folded limestones of the Appalachians than in the flat-bedded limestones of, say, the Interior Low Plateaus because dispersal routes are more likely to be disrupted and populations isolated. Examples of several invertebrates which evolved in isolated cave systems in the Greenbrier Valley of West Virginia were mentioned by Culver et al. (1974). Besharse and Holsinger (1977) described a new species of subterranean salamander from a cave in this valley. We recognize that this albino may represent a "stray" from a true cave-adapted population which is specifically distinct. However, the atypical features of the specimen, i.e., presence of a frenum, unusual dorsal and pelvic fin ray counts, and enlarged cephalic canal pores, may be environmentally induced. We feel that the assignment of a specific name is

not appropriate at this time, and hope that this report will stimulate speleologists and ichthyologists to search for additional albino *Cottus* in the caves of this area.

ACKNOWLEDGMENTS. — We wish to express our gratitude to the following individuals for their assistance with the preparation of this paper. John E. Cooper, North Carolina State Museum of Natural History, and C. Richard Robins, University of Miami, reviewed and made comments on the manuscript. J. A. Stellmack, Pennsylvania State University, collected and donated the specimen to John Cooper and provided information relative to its capture. James F. McKinney photographed the specimen. Field work was supported by a Samford University Faculty research grant to W. M. Howell.

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Accepted 10 January 1979

Occurrence of the Milliped *Pachydesmus crassicutis incursus* Chamberlin in the Kings Mountain Region of North Carolina and the Coastal Plain of South Carolina (Polydesmida: Xystodesmidae)

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ABSTRACT. — The milliped *Pachydesmus crassicutis incursus* Chamberlin is reported from specific localities in the Kings Mountain region of North Carolina, the northeastern limit of the genus, and the Piedmont and southern Coastal Plain of South Carolina. Males are generally larger than females, and individuals of both sexes are generally darker in color and larger in the Kings Mountain region than in the southern part of the range. Gonopodal variation is evident in the apical portion of the secondary tibiotarsus, especially in the subterminal process, which may be blunt, pointed, or absent. The secondary tibiotarsus is longer than the primary branch in individuals from southern South Carolina, but the two structures are subequal in specimens from the Kings Mountain region.

Millipeds of the genus *Pachydesmus* are the largest polydesmoids in North America. They occur in the southeastern states from South Carolina and Tennessee to eastern Texas, but tend to be secretive and are generally encountered less frequently than other xystodesmids. Hoffman (1958) recognized two species: *Pachydesmus clarus* (Chamberlin) and *P. crassicutis* (Wood), the latter represented by eight subspecies. The Mississippi River divides their ranges, with the former occurring on the western side and the latter on the eastern side. The easternmost representative, *P. crassicutis incursus* Chamberlin, inhabits the foothills of Georgia and South Carolina adjacent to the southeastern edge of the Blue Ridge Mountains, and is known definitely from Tallulah Falls, Habersham County, Georgia; and Easley, Pickens County, and Taylors, Greenville

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County, South Carolina. The sole North Carolina record is a male from an unspecified locality in the mountains, which Hoffman surmised was probably either near Tryon, Polk County, or "in Macon County between Franklin and Clayton, Ga."

In the summers of 1975 and 1976 we discovered *P. c. incursus* in moist seepage areas in the Kings Mountain region of North Carolina (Cleveland and Gaston counties), just across the border from South Carolina, and can now confirm its occurrence in the state. This area might be the one referred to previously, as it consists of several peaks over 300 m, two of which, the Pinnacle of Kings Mountain and Crowders Mountain, rise to 520 m and 495 m, respectively. However, the region is located in the south-central Piedmont Plateau Province, about 88.5 km east of the Blue Ridge Front, and lies within the range postulated by Hoffman for the subspecies. Nevertheless, the prior North Carolina record could conceivably be from the Kings Mountain region, since to our knowledge *Pachydesmus* has never been authentically collected from the Appalachian Mountain portion of the state.

Wray (1967) reported "*Pachydesmus retrorsus*" from "probably valley of French Broad River," western North Carolina. The specimen that he cited, however, was the questionable one from North Carolina that Hoffman had earlier (1958) identified as *P. c. incursus*. Thus, *P. retrorsus* does not occur in North Carolina and is hereby deleted from the fauna of the state. This error could have been avoided by simply reviewing Hoffman's paper, which also reduced *P. retrorsus* to a subspecies of *P. crassicutis*.

In the summers and springs of 1976-1977 the senior author collected *P. c. incursus* from 16 localities in the South Carolina Piedmont and two in the lowland region of the Coastal Plain. Of the Coastal Plain specimens, those from Barnwell County were found along the edge of a swamp in association with *Sigmoria latior hoffmani* Shelley, and the female from Jasper County was found under moist leaves in a live oak thicket. In the Piedmont, the milliped was encountered primarily in hardwood localities near water sources but was also taken from pine areas with thick vines and undergrowth. One female from Newberry County was discovered under pine-bark mulch on a walkway at Molly's Rock Picnic Area, Sumter National Forest, in a primarily pine forest. These collections indicate that the subspecies is common in the Piedmont and Coastal Plain of South Carolina and can probably be collected from similar habitats south of the Savannah River in Georgia.

The known North Carolina and new South Carolina localities for *P. c. incursus* are listed below. Except for two samples in the Florida State Collection of Arthropods (FSCA) and one in the American Museum of

Natural History (AMNH), all specimens are deposited in the invertebrate collection of the North Carolina State Museum of Natural History (NCSM).

NORTH CAROLINA: *Cleveland Co.*—6.6 km sw Kings Mtn. (town), along co. rd. 2245 at crossing of Dixon Branch Cr., 0.3 km nw jct. co. rd. 2283, 2 ♂, 3♀ (1 juv.), 16 August 1975, R.M. Shelley and J.C. Clamp (NCSM A537); 9.3 km s Kings Mtn. (town), along co. rd. 2245, 0.2 km n jct. co. rd. 2288, 3 ♀, 16 August 1975, R.M. Shelley and J.C. Clamp (NCSM A541); 9.1 km sw Kings Mtn. (town), along co. rd. 2283, 1.3 km ne jct. NC hwy. 216, 1♂, 8 July 1976, M. Filka and W.W. Thomson (NCSM A1060); and 4.8 km s Kings Mtn. (town), along co. rd. 2289, 1.0 km w jct. NC hwy. 161, 2 ♂, 18 October 1976, M. Filka and G. Wicker (NCSM A2239). *Gaston Co.*—8.5 km sw Gastonia, along co. rd. 1122 at Crowder Cr., 1.4 km w jct. co. rd. 1131, 2 ♂, 2 ♀, 16 August 1975, R.M. Shelley and J.C. Clamp (NCSM A547); 6.4 km sw Gastonia, along co. rd. 1126, 0.8 km s jct. co. rd. 1113, 1 ♀, R.M. Shelley and J.C. Clamp (NCSM A549); 7.7 km sw Gastonia, along co. rd. 1131, 0.2 km nw jct. co. rd. 1133, 1 ♀, M. Filka and W.W. Thomson (NCSM A1091); and 6.8 km w Gastonia, along co. rd. 1106, 2.4 km e jct. co. rd. 1236, 1 ♂, 16 October 1976, M. Filka and G. Wicker (NCSM A2255).

SOUTH CAROLINA: *York Co.*—Kings Mtn. State Park, ♂, 2♀, 20 August 1976, R.M. Shelley (NCSM A1361). *Chester Co.*—21.9 km w Chester, Woods Ferry Recreation Center, Sumter National Forest, 6♂, 4 August 1976, R.M. Shelley (NCSM A1363); and ♀, 1 May 1977, R.M. Shelley (NCSM A1504). *Union Co.*—11.7 km s Union, SC hwy. 16 at Tyger R., ♀, 5 August 1976, R.M. Shelley (NCSM A1364); and 10.3 km nw Union, SC hwy. 279 at Fair Forest Cr., 2♀, 2 May 1977, R.M. Shelley (NCSM A1509). *Newberry Co.*—14.9 km ne Newberry, Molly's Rock Picnic Area, Sumter National Forest, ♀, 5 August 1976, R.M. Shelley (NCSM A1365); 8.5 km s Whitmire, SC hwy. 32 at Indian Cr., ♀, 2 May 1977, R.M. Shelley (NCSM A1520); 18.8 km ne Newberry, SC hwy. 81 at Enoree R., 3♂, 2♀, 5 August 1976, R.M. Shelley (NCSM A1366); and 19.3 km sw Newberry, jct. SC hwys. 72 and 211, ♂, 6 August 1976, R.M. Shelley (NCSM A1367). *Saluda Co.*—8.5 km ne Saluda, along SC hwy. 39, 1.4 km n jct. SC hwy. 450, ♀, 4 May 1977, R.M. Shelley (NCSM A1527). *Greenwood Co.*—19.1 km s Greenwood, along SC hwy. 48, 0.2 km w jct. SC hwy. 63, ♂, 9 August 1976, R.M. Shelley (NCSM A1371); and 19.3 km se Greenwood, unnumbered rd. at Cuffytown Cr. along edge of Sumter National Forest, ♀, 9 August 1976, R.M. Shelley (NCSM A1372). *Oconee Co.*—9.1 km se Oakway, SC hwy. 66 at Beaverdam Cr., ♂, 10 June 1978, R.M. Shelley and W.B. Jones (NCSM A2062). *McCormick Co.*—6.6 km se Plum Branch, SC hwy. 21 at Stephen's Cr., ♀, 5 May

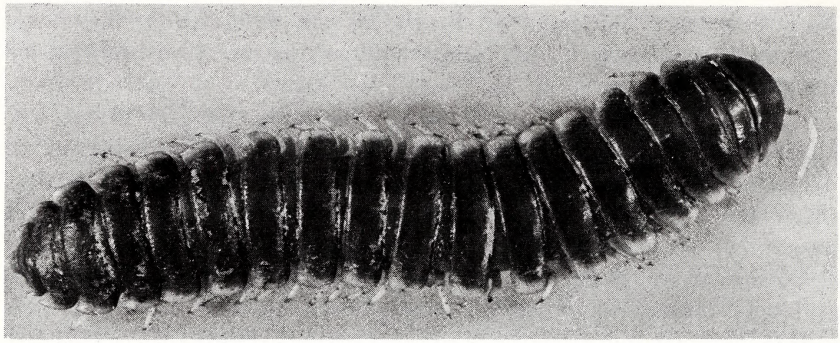


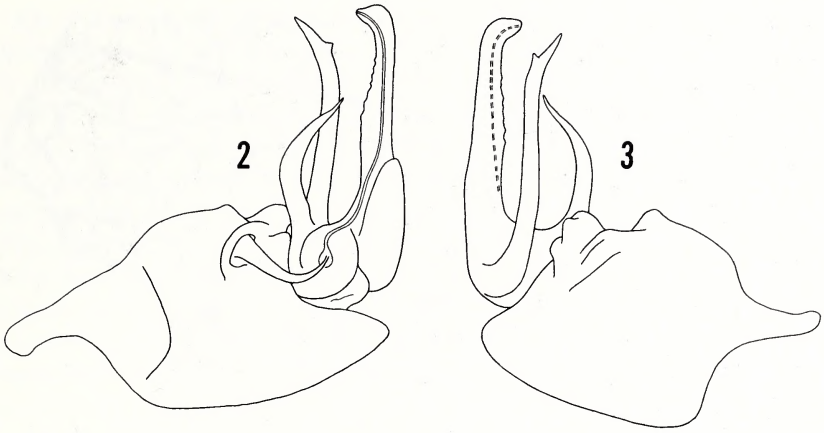
Fig. 1. Dorsal view of ♀ *Pachydesmus crassicutis incursus* from 9.3 km s Kings Mountain (town), Cleveland County, North Carolina. Total length 63.8 mm.

1977, R.M. Shelley (NCSM A1535); Baker Creek State Park, 3♂, ♀, 8 August 1976, R.M– Shelley (NCSM A1369); Hickory Knob State park, ♀, 9 August 1976, R.M– Shelley (NCSM A1370); and 7.4 km n Mt. Carmel, SC hwy. 46 at Little R., ♂, ♀, 5 May 1977, R.M. Shelley (NCSM A1542). *Laurens Co.*—15.8 km n Laurens, SC hwy 97 at Beaver Dam Cr., ♀, 9 May 1977, R.M. Shelley (NCSM A1567). *Orangeburg Co.*—Orangeburg, 4♂, 2 juvs., 20 July 1961, D. Dowling (FSCA), and 4♂, ♀, 3 August 1961, D. Dowling (FSCA). *Barnwell Co.*—Barnwell State Park, 5 ♂, 7 August 1976, R.M. Shelley (NCSM A1368). *Jasper Co.*—12.9 km s Hardeeville, along US hwy 17A, 0.6 km w SC hwy. 170A, ♀, 2 July 1977, R.M. Shelley (NCSM A1601); and Ridgeland, ♀, 6 April 1975, D. Brody (AMNH).

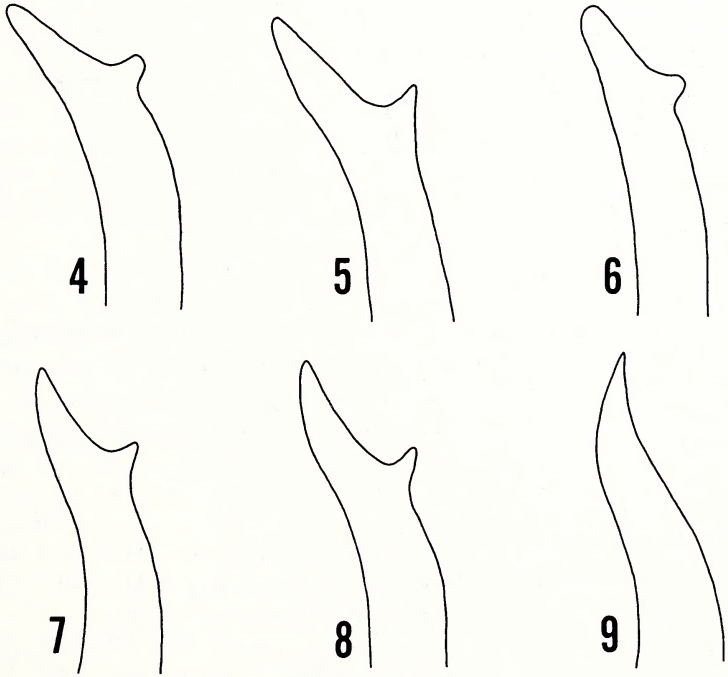
Only three males of *P. crassicutis incursus* were examined by Hoffman for his revision, and all had been preserved since early this century. We therefore submit the following observations on color, body proportions, and gonopod variation to supplement his description.

In life most individuals are dark, chocolate brown dorsally with light yellow paranota (Fig. 1); the venter is a little lighter in color than the paranota. Specimens from Barnwell and Greenwood counties, South Carolina, are light, brownish-gray dorsally with cream-colored paranota.

The body dimensions of males and females collected in the summer of 1976 are shown in Table I. Males are generally longer and wider than females and have a higher W/L ratio. Individuals of both sexes are larger in the Kings Mountain region and become smaller in a south-south-eastward direction. This correlates with the paling of body color and probably reflects more favorable environmental conditions in the Kings Mountain region.



Figs. 2-3. Left male gonopod of *Pachydesmus crassicutus incursus* from 9.3 km s Kings Mountain (town), Cleveland County, North Carolina. Drawn x50. 2, medial view. 3, lateral view.



Figs. 4-9. Apical variation of secondary tibiotarsus of *Pachydesmus crassicutis incursus*. Specimens from Woods Ferry Recreation Center, Chester County, South Carolina. Medial views, drawn x100.

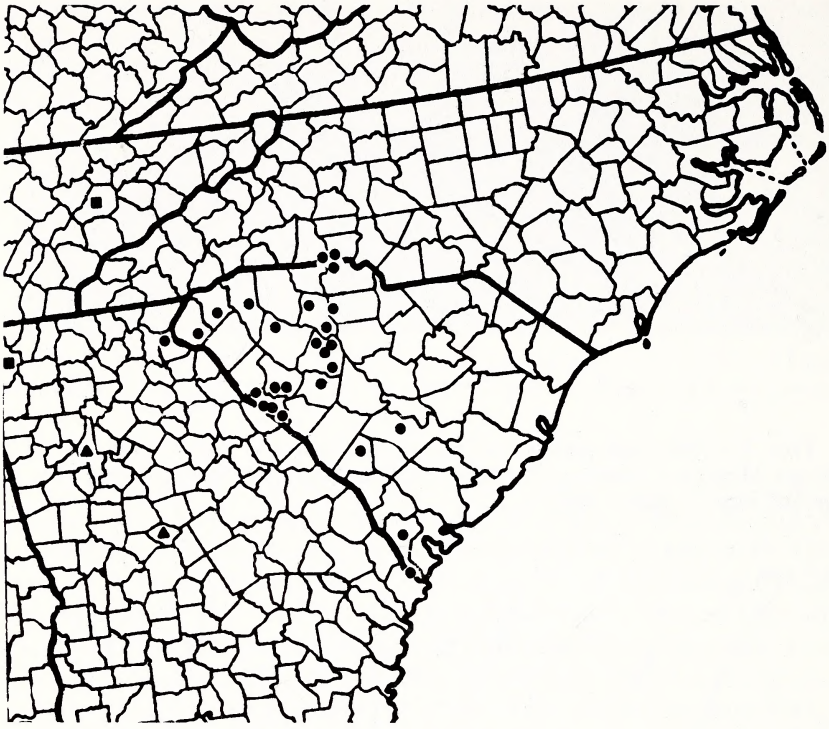


Fig. 10. Distribution of *Pachydesmus crassicutis* in southeastern United States. ● = *P. c. incursus*; ▲ = *P. c. denticulatus*; and ■ = *P. c. retrorsus*.

Table 1. Body dimensions of *Pachydesmus crassicutis incursus* (all measurements are averages and in mm.)

	♂				♀			
County	No. inds.	W	L	W/L%	No. inds.	W	L	W/L%
Cleveland, NC	3	12.0	62.8	19.2	5	11.2	69.0	17.8
Gaston, NC	2	13.2	66.9	19.7	3	11.9	65.5	18.1
York, SC	1	12.6	61.7	20.4	2	11.2	57.7	19.4
Chester, SC	6	12.3	63.0	19.5				
Union, SC					1	11.8	63.6	18.6
Newberry, SC	4	10.9	57.2	19.1	2	11.4	61.7	18.5
Greenwood, SC	1	10.8	56.5	19.1	1	9.9	54.7	18.1
McCormick, SC	3	11.5	60.9	18.8	1	11.2	54.8	20.4
Barnwell, SC	4	10.2	52.6	19.3				

On the gonopods (Figs. 2, 3), the subapical process of the secondary tibiotarsus is reduced from the configuration depicted by Hoffman (Figs. 7c and 8c, pp. 201 and 203), so that it appears as a small tooth on the main stem of the structure. It may be blunt or pointed (Figs. 4-9) and is absent from one male from Chester County (Fig. 9). Similarly, the apical portion of the secondary tibiotarsus varies and may be blunt or pointed and curved distad or ventrad (Figs. 4-9). The primary and secondary tibiotarsi are subequal in length in specimens from North Carolina and York, Chester, and Newberry counties, South Carolina, but the latter is slightly longer in specimens from the southern part of the range. Denticulations along the anterior edge of the primary tibiotarsus vary and are essentially absent from some gonopods. The coxal apophysis and the remainder of the gonopod are as described by Hoffman (1958).

This increased knowledge of variation of *P. c. incursus* does not affect the status of *P. c. denticulatus* Chamberlin, which occurs in the Piedmont region of north-central Georgia. The two subspecies are distinguished by several features, most notably the configuration of the coxal apophysis, which is tri-lobed in *P. c. incursus* and smoothly rounded with the distal margin entire in *P. c. denticulatus*.

The range of *P. crassicutis incursus* can thus be expanded to include the Kings Mountain region of North Carolina and the Piedmont and Coastal Plain of southern South Carolina (Fig. 10). Efforts to find the diplopod in North Carolina adjacent to the Kings Mountain region have been unsuccessful, and this area therefore represents the known northeastern range limit of the genus.

ACKNOWLEDGMENTS.—We thank John C. Clamp and William W. Thomson for assistance in collecting *Pachydesmus* from North Carolina; Howard V. Weems, Jr., for access to material in the FSCA; and Norman I. Platnick, for access to that in the AMNH. Specimens from Kings Mountain, Barnwell, Baker Creek, and Hickory Knob State Parks, South Carolina, were collected with permission of the S. C. Department of Parks, Recreation, and Tourism, Division of State Parks. The photograph is courtesy of Curtis Wooten, N. C. Wildlife Resources Commission.

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Accepted 8 November 1978

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